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THE GENESIS OF NATURE

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THE

GENESIS OF NATURE

CONSIDERED IN THE LIGHT OF MR. SPENCER'S PHILOSOPHY, AS BASED UPON THE PERSISTENCE OF ENERGY

BY

THOMAS H. MUSICK

" *Science commits suicide when she adopts a creed.*"—Huxley.

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1890

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PREFACE.

If apology be in place for this fresh adventure into the endless diversion of book-making, it is to be found in the altogether novel treatment of a subject of the very first importance. Conservation of Energy is a doctrine everywhere received as of universal application. So far as known, no other author has ever subjected it to controversial criticism. If true as generally accepted, discussion will do no hurt; if in any respect erroneous, it has long enough held place as the bottom fact in mind and nature, long enough served as the very bed-rock in physical science, long enough yielded vantage-ground to the assaults of Materialism upon spiritualistic faiths.

Should it be thought that the discussion is pursued with tedious particularity and iteration, let it be remembered that accepted error, no less than accepted truth, is hemmed in by triple walls of affection, fashion, and admiration, collectively known as *prejudice*, all of which must be breached before the missiles of reason can find lodgment. So, too, the charm of authority is equally potent in science and philosophy as in other lines of thought, for here, as elsewhere, many a time a great name has lain square across the pathway of truth, so that for ages no man would dare to bridge it over or plow it around.

Hence, it is scarce to be expected that the suggestion of grave errors by such masters in physics as Galileo and Newton, Mayer and Grove, Helmholtz and

Joule, Tyndall and Stewart, will be received with either patience or complacency.

Appreciating, therefore, the magnitude of the difficulties lying in the way of an unprejudiced consideration of the issues here raised, it has been deemed important to fortify the propositions presented by a closer analysis of current physical philosophy and a broader scope of argument than would seem, under other circumstances, to be necessary. And especially, in justification of the opinion that the great scientists of the age are not entitled to monopolize the attention of the thinking world, even in the presentation of the principles of physical science, the lack of precision and coherence manifested in the views of several of them is insisted upon with considerable particularity.

And, further, because Mr. Spencer's magnificent system is the most successful attempt to explain the universe of mind and matter ever yet formulated, Persistence, the basis of his all-embracing philosophy, is made the pivot of this discussion.

It only needs to be added that no other favor is expected or asked for the propositions and arguments here advanced, than that they be read and considered in a spirit of independence and loyalty to truth like to that which has guided the pen in this presentation.

WASHINGTON, D. C., September 22, 1890.

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THE GENESIS OF NATURE.

CHAPTER I.

INTRODUCTORY SURVEY—FACT AND HYPOTHESIS—AUTHORITY.

INTRODUCTORY SURVEY.

§ 1. There are and can be, on a last analysis, but two theories of the Genesis of Nature, the one, that of its creation and government by a personal Deity, the other, that of its self-development, by the self-exercise of impersonal, inherent, internal and eternal principles, acting under impersonal, self-contained, and eternal laws. All systems of philosophy and religion may be trimmed down to the one or the other of these theories, or to an illogical and destructive intermingling of the two. The question of the ages is, not as is often supposed, how much of one and how much of the other of these antagonistic theories are true? but which one of them is absolutely true and which one absolutely false? For no platform can ever be built broad enough to present standing room for both or any part of both at once.

Says John Burroughs: "Out of the potencies of matter itself, science traces the evolution of the whole order of visible things." *P. S. M., Dec.*, 1886, *p.* 154.

"The most advanced science of our time does not regard life as a special and separate principle, a real entity which has been added to matter, but as a mode in which certain physical forces manifest themselves, just as heat is not a thing of itself but a mode of motion." *Ibid*, 155.

Prof. John Draper says: "The hypothesis of EVOLUTION is that from one or a few original organisms, all those that we see have been derived by a process of evolving or development. It will not admit that there has been any introduction of divine power.

"The former of these hypotheses" (that by creation) "considers each species as independent of all the others; the second considers them as inter-related. Creation reposes on the arbitrary act of God; evolution on the universal reign of law." *P. S. M.*, *Dec.* 1877, p. 176.

Prof. Joseph Le Conte says: "To the deep-thinker, now and always, there is and has been the alternative —materialism or theism. God operates Nature or Nature operates itself." *Evolution and Religious Thought.*

Says W. S. Lilly: "Either Nature is the outcome of intellect, or intellect is the outcome of Nature." *P. S. M.*, *Feb.*, 1887, *p.* 476.

Says George Von Gitzycki: "The investigation has to break with theology in all its forms; and, even in ethics, the question of the object of the destiny of man will have to be given up." *P. S. M.*, *July*, 1885, *p.* 370.

Says Dr. Emily White: "That which is called *the ego*—the sum of the various elements which make up the character—cannot, from a scientific point of view, be regarded as an entity, unless the combined forces and powers of a machine may be so regarded." *P. S. M.*, *June*, 1877, *p.* 183.

Says Prof. George N. Williams: "As far as we can judge of the phenomena presented by the organic and mineral worlds, they differ rather in degree than in kind."

"In his recent annual address, the well-known President of the Geological Society of London, Prof. John. W. Judd, has attempted to throw aside entirely the distinction between crystallized and living matter, and to bring the phenomena of change observed by the microscopist in rocks within the limits of such definitions of life as those of Lewes and Spencer." *P. S. M., Sept.*, 1889, *p.* 646.

§ 2. Every occupation and every profession has its facts and its theories. The farmer has many facts of climate and soil and vegetable and animal life for his guidance, and he, likewise, has many theories of sowing, and tilling, and reaping. And so it is with the artist, the mechanic, the tradesman, and the carrier. So it is with the physician, the lawyer, and the statesman. They all have both facts and theories. And so it is, preëminently, with the scientist. Science is made up, in no very unequal parts, of facts and hypotheses or theories.

§ 3. That gravitation acts directly as the masses and inversely as the squares of the distances are facts. That this action is either a pushing force, or a pulling force, (*actio in distans*,) are theories, mere inferences drawn from the facts mentioned. That gravitation is an inexhaustive force is a fact not only of ready experiment but of common observation. That its inexhaustibility is an attribute of matter, or a continuous new creation, or an inpouring from some source outside the visible universe,—whichever, if either, be adopted, is but an hypothesis.

§ 4. That a body projected vertically upward, will, upon reaching its highest point of ascent, turn and retrace its path, traversing, in reversed order, the same distances in the same periods of time are facts. That the upward projectile force will be transformed into the downward falling force is only an hypothesis, and one, which, as will abundantly appear hereafter, is right in the teeth of an admitted fact that the body falls by reason of its gravity. And, therefore, while it is a fact that during the ascent the projectile force is continually exhausted, it is only an hypothesis that such exhaustion is simply a metamorphosis into *potential energy;* and while it is a fact that if it be caught on the top of a house or a cliff it will lie there until it is dislodged, it is only an extension of the same hypothesis that, while so resting, the upward projectile force is still in it, sleeping in the supposed form or mode of such *potential energy* until the dislodgment when it will appear again as *actual energy.*

§ 5. It is a fact that matter is submissive to force, but only a theory that it is equally indifferent to rest and motion. Therefore, while it is a fact that motion can be destroyed or changed in direction or speed by force alone, it is only an hypothesis that "a body acted upon by no force" can have any motion, whatever. And, further, while Kepler's three laws are facts, it is only a theory that the orbital motions of the planets are continually bent into curves by the pulling of gravity instead of being the result of a true composition of forces. And, again, while the law of the parallelogram of forces is a fact, its explanation as a composition of velocities instead of a composition of forces is but an hypothesis.

§ 6. That *vis viva* is as the squares of velocities is a fact, but that the explanation lies in the nature of the acting force instead of inhering in the character of the resistance overcome is another hypothesis.

Turning to the problems of molecular forces we find fact and hypothesis intermingled in the same manner. That the heat-force of the sun is continually dissipated into the voids of space is a fact, that it is in any way conserved or returned to the sun is a theory; that by the aid of sunlight plants decompose carbonic dioxide, setting the oxygen free and deposit ing the carbon in the vegetable tissues is a fact; that all the force which drives the mill-wheel or the locomotive is but that of the transformed sunshine which has been sleeping for untold ages in the coal used as fuel, is a beautiful theory. So it is a fact that more or less heat is exhibited in all friction and percussion, but that all the molar force of the friction or impact is converted into heat is theoretical; perhaps, as yet, it is only theory that any of it is so converted. The Law of Mariotte and the Law of Charles are facts, the Law of Avogadro is an hypothesis.

§ 8. And so we might continue at great length, but it is unnecessary. The point here, however, is to call attention to the fact that many of these hypotheses mentioned, as well as many others not mentioned, are accepted by scientists, generally, with the same abiding confidence and faith as are shown to the facts of observation and experiment. And this is the weakness of science. Scientific facts are as irrefragable as any other class of facts, while scientific theories are worth no more than theories in any other sphere of thought. And, further, while full credit and confidence should be given to scientists in the discussions of the experiential facts in their several lines, it does not follow that their *dicta* should be followed as absolute authority when they are only propounding theories. A theory is at best but an inference from facts, and it by no means follows that because a man has an exhaustive knowledge of the facts pertaining to his specialty, that he of all men is most likely to be right in the inferences to be drawn from such facts. It is a saying of Galileo's, that "In questions of science, the authority of a thousand is not worth the humble reasoning of a single individual." And Prof. Tyndall has said: "Authority caused me for weeks to depart from the truth, and to seek counsel among delusions. It is not only injurious but deadly, when it cows the intellect into questioning it." In the following chapters, therefore, while accepting everything which science presents with sufficient apparent basis in fact for the mind to receive with abiding confidence, I have, without hesitation, subjected all hypotheses and theories which have fallen in my way to the most exhaustive analysis, notwithstanding the fact that many of them have conquered the homage of the scientific world. I have not in any instance stopped to question what any one or all of earth's great thinkers have said or may say on any proposition, until I have proposed and answered to myself as best I could, two interrogatories: Is it fact or theory? If the latter, what are its ascertainable basis and supports? This has brought me much in conflict with several of the great modern philosophical *theories*, which, having outgrown the tutelage of the scientific world, have become the common property of the intelligent of our race amongst all classes. I say *theories* advisedly, for, although, generally, and some of them universally accepted as facts, they are but inferences drawn from facts, and in many instances, as I think, erroneously drawn.

Of course an inference logically drawn from enough of the facts in any case is as indubitable as the facts themselves, but the contention here is that no man is entitled to a monopoly in reasoning on any set of facts, so that it is always open to B. to show, if he can, that A's inferences are illogical or illegitimate. If he succeeds, it is so much the better for truth; if he fails, it is so much the worse for B.

§ 9. This position is taken with full knowledge that Science, like everything else human, has its modes of fashion, and there, as elsewhere, "one had as well be out of the world as out of fashion;" with full knowledge that science is as impatient and intolerant, almost, of contradiction as ever the Church was; with the fact before me that so great a Scientist as Prof. Tait in his scorn, has "contemned and condemned," all that "herd of ignorant people," who refuse to accept all the suppositions and fancy woven theories, christened *Facts* by present-day science, "to their proper fate—oblivion."

But while refusing to allow my free thought on lines, penetrating, not only to the basis of physical science and philosophy, but to the mystery of life and the destiny of mind as well, to be "chained to the chariot wheel" of authority, I permit no one to precede me in my admiration and reverence for the great names who have made the achievements of the last four hundred years grander than all those of the preceding four thousand, and the achievements of the last one hundred grander than all those of the preceding four hundred.

CHAPTER II.

TWO SCHOOLS OF EVOLUTION.—DESIGNED AND DESIGNLESS.—ARGUMENTS, HISTORICAL, PHILOSOPHICAL AND NEGATIVE.—SPENCER'S SYSTEM OF EVOLUTION — DARWIN'S— LAMARCK'S— COPE'S — BASTIAN HINTON.

Evolution.

§ 10. The doctrine of evolution is the latest general inducation of philosophic research, and it has been very generally, it may almost be said universally, accepted by all who make pretensions to scientific culture. As received by some it does no more than cover and include the whole process of creation; as interpreted by others, it constitutes the very basis of the philosophy of creation, or rather, it is that philosophy itself, and by it must be moulded, not only every scientific theory and opinion, but every ethical principle and religious faith as well.

Two Schools of Evolution.

For in discussing the great question whether the Universe, as we know it, is the product of design or otherwise, the handiwork of the Deity or the result of fortuitous action, God-created or self-grown, it needs to be remembered that, while many learned Theists insist, not only that God made the worlds with all their garniture and inhabitants, but, further, that He formed them by and through evolutionary methods and processes; all those of the present day, almost perhaps, without exception, who discard will, plan, and purpose in creation, predicate their objections to a personal Deity, and build their arguments and find their sufficient reasons for all things that be in the doctrines of evolution. In other words, while the Agnostics, Materialists, and Pantheists of the present age bottom their beliefs wholly upon the philosophy of evolution, to the entire exclusion of a designed creation, evolutionary Theists, on the contrary, contend that the theory is susceptible of conformity to the doctrine of a purposing Deity, if not of rendering logical support to that ancient embodiment of faith and philosophy.

§ 11. And the difference between the two evolutionary schools, though not often distinctly outlined, perhaps not often even definitely observed, is logical and radical. The one limits evolution to the processes—that is, to the modes or manner of operation of some Power in creation, which may or may not be defined, acting freely according to His own self-determined laws and under His own self-imposed restrictions; the other attempts to trace, not only the processes of creation, but the genesis of the forces concerned, and the laws under which they act as well, to and through the principles of evolution. The latter school must, therefore, ignore all purpose or design in creation, for, if the very forces active in the universe and the laws under and by which their actions are determined are all the products of evolution, then there is no room left for plan, purpose, or design. A purpose which can determine no process is nugatory. A plan to which the planner can compel no activity to conform is still-born. A cause which does not possess a present efficiency is no cause at all. "A Great First Cause" not freely imminent and actively present in nature is not an efficient cause. A Deity, whether called "Jehovah, Jove, or Lord," God, or "The Unknowable," who does not both possess and exert an efficient determining power over the universe, is practically not Deity at all. It matters little what men may be pleased to call themselves or what others may be pleased to call them. If they find in nature need for a self-willing, self-purposing, self-acting, present, efficient personality, they are practically Theists. If, on the contrary, they find that nature built up and now sustains herself by impersonal laws, forces, and processes; that, by reason of inherent principles, she originated and now runs herself; that every to-day is the necessary outcome of the conditions of the yesterday, and every yesterday of the conditions of the day before—then they are not practical Theists, whatever they may call themselves. For, it is a pointed contradiction in terms to declare that any given *status* in nature is the inevitable result of certain inherent principles and laws, and at the same time to admit that it is in any manner or to any extent or degree the result of purpose or dependent upon any personal will, however wise or powerful, whatsoever called or wheresoever located.

§ 12. That there may be no room for ambiguity the two doctrines may be further defined and contrasted: Creation means the production of all things by an exterior and superior power; undesigned evolution may be taken to mean that all nature, as we know it, has been constructed by inherent principles, through a gradual process of unfolding, upgrowth, and outgrowth, or, as Mr. Herbert Spencer terms it, of aggregation and segregation. The cause, in the former, is personal; in the latter, if cause it may be called, is impersonal. The former presumes anterior plans and purposes; in the latter there are no prior plans, because no prior planner. The former makes creation the result of the activity of nature's forces, marshalled and directed by a personal, voluntary Intelligence, on a plan, for a purpose, and to an end; designless evolution is simply the result of the action, re-action, and inter-action of interior principles—some philosophers say "forces"—under and according to inherent, necessary, and inexorable laws. In the one nature is the workmanship of a free, intelligent Personality; in the other, a grist from the relentless mill of destiny; a product of inexorable Fate itself. In the former, there is scope for the free volition of the human will and room for faith in a prayer-hearing and prayer-answering God of providence; in the latter, the soul of man is but a cog in the great machine, inevitably moulded, fitted, and fixed in its groove, its destiny to crush and be crushed forever as the creaking mill grinds on, with none to listen and none to heed. The "mills of the gods" grinding slowly but exceeding fine become the iron decrees of eternal Fate, as old as the nebular dust of creation itself.

§ 13. A few references will show that the position of extreme Evolutionists has not been misstated. Says that great German thinker, Haeckel: "The general theory of evolution assumes that in nature there is a great unital, continuous and everlasting process of development, and that all natural phenomena without exception, from the motion of the celestial bodies and the fall of the rolling stone to the growth of the plant and the consciousness of man are subject to the same great law of causation—that they are ultimately to be reduced to atomic mechanics. This is the only scientific theory which affords a rational explanation of the universe and satisfies the craving of the intellect for causal connections, inasmuch as it links all the phenomena of nature as parts of a united process of development and as a series of mechanical causes and effects."—*Modern Physics, p.* 20.

"I maintain with regard to the much talked of purpose in nature," that it really has no existence but for those persons who observe phenomena in animals and plants in the most superficial manner."—*History of Creation, Vol. II, p.* 19.

"Scientific materialism, which is identical with our Monism, affirms in reality no more than that everything in the world goes on naturally—that every effect has its cause, and every cause its effect. It, therefore, assigns to causal law—that is, the law of a necessary connection between cause and effect; its place over the entire series of phenomena that can be known. At the same time Scientific Materialism positively rejects every belief in the miraculous, and every conception, in whatever form it appears, of supernatural processes. Accordingly, nowhere in the whole domain of human knowledge does it recognize real metaphysics, but, throughout, only physics; through it the inseparable connection between matter, form, and force becomes self-evident. This scientific materialism has long since been so universally acknowledged in the wide domain of inorganic science, in physics and chemistry, in mineralogy and geology, that no one now doubts its authority. But in biology, or organic science, the case is very different: here its value is still continually a matter, of dispute in many quarters. There is, however, nothing else which can be set up against it, excepting the metaphysical spectre of a vital power or empty theological dogma. If we can prove that all nature, so far as it can be known, is only *one;* that the same great, eternal iron laws are active in the life of animals and plants, as in the growth of crystals and in the force of steam, we may, with reason, maintain the monistic or mechanical view of things throughout the domain of biology, in zoology and botany, whether it be stigmatized as material or not. In such a sense all exact science, and the law of cause and effect at its head, is purely materialistic."—*Ibid, p.* 35.

"In order, then, to avoid in future the usual confusion of this utterly objectionable Moral Materialism with our Scientific Materialism, we think it necessary to call the latter either *Monism* or *Realism.* The principle of this *Monism* is the same as what Kant terms the 'principle of Mechanism', and of which he expressly asserts, that *without it there can be no natural science at all.* This principle is quite inseparable from our non-miraculous history of creation, and characterizes it as opposed to the theological belief in the miracles of a supernatural history of creation."—*Ibid, p.* 37.

"I will only add that this wonderful theory," (Kant's theory of evolutionary creation) "which might be called *the Cosmological Gas Theory*, harmonizes with all the general series of phenomena at present known to us, and stands in no irreconcilable contradiction to any one of them. Moreover, it is purely mechanical or monistic, makes use exclusively of the inherent forces of eternal matter, and entirely excludes every supernatural process, every pre-arranged and conscious action of a personal Creator. Kant's Cosmological Gas Theory consequently occupies a similar supreme position in *anorganology*, especially in *geology*, and forms the crown of our knowledge in that department, in the same way as Lamarck's Theory of Descent does in *biology*, and especially in *anthropology*. Both rest exclusively upon mechanical or unconscious causes (*causæ efficientes*), in no case upon pre-arranged or conscious causes (*causæ finales*). Both, therefore, fill all the demands of a scientific theory, and, consequently, will remain generally acknowledged until they are replaced by better ones."—*Ibid, p.* 323.

"The universe is unlimited and immeasurable in both space and time. It is eternal and it is infinite. Nor can we imagine a beginning or end to the uninterrupted and eternal motion in which all particles of the universe are always engaged. The great laws of the *conservation of force* and the *conservation of matter*, the foundations of our whole conceptions of nature, admit of no other supposition. The universe, so far as it is cognizable to human capability, appears as a connected chain of material phenomena of motion, necessitating a continual change of forms. Every form, as the temporary result of a multiplicity of phenomena of motion, is as such of perishable, and limited duration. But, in the continual change of forms, matter and the motion inseparable from it remain eternal and indestructible."—*Ibid. p.* 324.

Lamarck says: "Life is purely a physical phenomenon. All the phenomena of life depend on mechanical, physical and chemical causes, which are inherent in the nature of matter itself. The simplest animals, and the simplest plants, which stand at the lowest points in the scale of organization, have originated and still originate by spontaneous generation. All animals, natural bodies, or organisims are subject to the same laws as inanimate natural bodies or anorgana. The ideas and actions of the understanding are the motional phenomena of the central nervous system. The will is in truth never free. Reason is only a higher degree of development and combination of judgment."

Emil Du Bois-Reymond says: "The possibility, however remote, of banishing out of nature this apparent adaptation to ends (teleology), and of everywhere setting up blind necessity in the place of final causes, is to be regarded as one of the greatest advances ever made in the world of thought, as a step from which will be dated a new epoch in the treatment of these problems."—*P. S. M., Feby.*, 1879, *p.* 413.

"Final causes in nature are incompatible with nature's intelligence. Hence, if there is any way of banishing teleology from nature, the man of science is bound to take it."—*Ibid. p.* 421.

"For us there is no other knowledge save mechanical knowledge, however beggarly a substitute that may be for true knowledge, and consequently there is only one truly scientific form of thought—the physico-mathematical one. Hence there can be no more mischievous illusion than that whereby we are led to believe that we explain the teleology of organic nature by calling in our aid an immaterial intelligence, conceived to our own likeness and working for ends."—*Ibid*, *p*. 423.

"Natural science—or, more definitely, knowledge of the physical world with the aid and in the sense of theoretical natural science—means the reduction of all change in the physical world to movements of atoms produced independently of time by their central forces; or, in other words, natural science is the resolution of natural processes into the menchanics of atoms." *P. S. M.*, *May*, 1874, *p*. 17.

"If we were to suppose all changes in the physical world resolved into atomic motions, produced by constant central forces, then we should know the universe scientifically. The condition of the world at any given moment would then appear to be the direct result of its condition in the preceding moment, and the direct cause of its condition in the subsequent moment. Law and chance would be only different names for mechanical necessity."—*Ibid*, *p*. 18.

Says William D. Le Seur: "What every one can at once remember is, that the writers who are called agnostics, the Spencers, Huxleys, Tyndalls, and Darwins plead for the universality of nature's laws and the abiding uniformity of her processes." *P. S. M. April*, 1884, *p*. 784.

"The scientific world is not aware that nature has any ends in view, or is capable of having any ends in view, which she needs the help of man to enable her to realize. Science does not attribute purpose to nature. Science has simply obtained a glimmering of how, in point of fact, nature works. —*Ibid*, 791.

Grant Allen says: As in the cosmos so in the solar system itself, evolutionism has taught us to regard our sun, with its attendant planets and their ancillary satellites, all in their several orbits, as owing their shape, size, relations and movements, not to external design and deliberate creation, but to the slow and regular working out of physical laws, in accordance with which each has assumed its existing weight and bulk, and path, and position."—*Pop. Sci. Month.*, *Aug.*, 1887, *p.* 506.

"It," (science) "reconstructs for us from obscure half-hints the origin of man; the earliest stages of human history, the rise of speech, of arts, of societies, of religion. It unifies and organizes all our concepts of the whole consistent system of nature, and sets before our eyes the comprehensive and glorious idea of a cosmos which is one and the same throughout, in sun and star and world and atom, in light and heat and life and mechanism, in herb and tree and man and animal, in body, soul and spirit, mind and matter."—*Ibid*, *p.* 518.

"Evolution implies continuity and uniformity. It teaches us to look upon events of all kinds as the products of continuously operating causes—it recognizes no sudden breaks or causeless stoppages in the sequence of natural phenomena. It equally implies that natural events do not vary spontaneously. It is a philosophy which deals with natural phenomena in their widest sense; it embraces both the present and the far distant past. It seeks to assure us that the properties and tendencies now manifest in our surrounding world of things are in all respects similar to those which have existed in the past. Without a basis of this kind, the evolution hypothesis would be a mere idle dream."—*Dr. Bastian*, *P. S. M.*, *Apr.* 14, *p.* 714.

"Now, the evolutionist repudiates the notion of creation in its ordinary sense; he believes that the operation of natural causes, working in their accustomed manner, was alone quite adequate to bring into existence a kind of matter presenting a new order of complexity, and displaying the phenomena which we have generalized under the word 'Life.' Living matter is thus supposed to have come into being by the further operation, under new conditions, of the same agencies as had previously led to the formation of the various inorganic constituents of the earth's crust—such mineral and saline substances as we see around us at the present day. What we call 'Life,' then, is regarded as one of the natural results of the growing complexity of our primal nebula. So that, in accordance with this view, we have no more reason to postulate a miraculous interference or exercise of creative power to account for the evolution of living matter in any suitable portion of the universe (whether it be on this earth or elsewhere), than to explain the appearance of any other kind of matter—the magnetic oxide of iron, for instance."—*Ibid, p.* 717.

Prof. Huxley says: "Carbon, hydrogen, oxygen, and nitrogen are all lifeless bodies. Of this, carbon and oxygen unite in certain proportions and under certain conditions to give rise to carbonic acid; hydrogen and oxygen produce water; nitrogen and hydrogen give rise to ammonia. These new compounds, like the elementary bodies of which they are composed, are lifeless. But, when they are brought together under certain conditions, they give rise to the still more complex body, protoplasm; and this protoplasm exhibits the phenomena of life. *Ibid, p.* 725.

Herbert Spencer says: "Evolution, as I understand it, and creation, as usually understood, are mutually exclusive: if there has been that special formation and adjustment commonly meant by creation, there has not been evolution; if there has been evolution, there has not been special creation. Similarly, unchangeable laws, as conceived by a man of science, negative the current conception of divine government, which implies interferences or special providences: if the laws are unchangeable, they are never traversed by divine volitions suspending them; if God alters the predetermined course of things from time to time, the laws are not unchangeable."—*P. S. M., Feb.*, 1874, *p*. 493.

Mr. George Iles says: "One result of science will be profoundly influential here: its arrival at the idea of law, its perception of uniformity and constancy in Nature; the proof of which in large part, it now possesses, that the history of the universe from nebular mist to man illustrates causation and continuity. This idea, excluding as it does the miraculous and the supernatural, leads us to regard the history of the universe as an unbroken and consistent unfolding." *P. S. M., May*, 1885, *p*. 61.

Prof. Tyndall says: "Trace the line of life backward, and see it approaching more and more to what we call the purely physical condition. We reach at length those organisms which I have compared to drops of oil suspended in a mixture of alcohol-and-water. We reach the *protogenes* of Haeckel, in which we have a type distinguishable from a fragment of albumen only by its finely granulated character. Can we pause here? We break a magnet, and find two poles in each of its fragments. We continue the process of breaking, but, however small the parts, each carries with it, though enfeebled, the polarity of the whole. And, when we can break no longer, we prolong the intellectual vision to the polar molecules. Are we not urged to do *something* similar in the case of life? Is there not a temptation to close to some extent with Lucretius, when he affirms that Nature is seen to do all things spontaneously of herself without the meddling of the gods? or, with Bruno, when he declares that matter is not that mere empty capacity which philosophers have pictured her to be, but the universal mother, who brings forth all things as the fruit of her own womb? The questions here raised are inevitable. They are approaching us with accelerated speed, and it is not a matter of indifference whether they are introduced with reverence or irreverence. Abandoning all disguise, the confession that

I feel bound to make before you is that I prolong the vision backward across the boundary of the experimental evidence, and discern in that matter, which we in our ignorance, and notwithstanding our professed reverence for its Creator, have hitherto covered with opprobrium, the promise and potency of every form and quality of life."—*Belfast Address.*

Prof. Youmans says: "Those who deny spontaneous generation, or that living beings are directly engendered out of matter, are only able to do so by prolonging their vision beyond the sensible evidence, and assuming that nature is pervaded by infinitely tenuous, inscrutable, though still material life-germs. But, whatever the processes by which Nature breaks into this multitudinous life, it is undoubtedly done through an inflexible system of law. There is no irregularity, caprice, or miracle, about it; it is a phase of the established order of things, and vital effects can no more be dissociated from the properties and powers of matter than chemical or physical effects." —*P. S. M., Nov.,* 1874, *p.* 112.

§ 14. It is evident, therefore, that in discussing the great proposition of self-creation, or, in other words, in considering the alternatives of design or no design in nature, an exhaustive review and analysis of designless evolution in all its phases becomes necessary in order that what of established truths, what of uncertainty, and what of error there may be in it may be sifted and distinguished and the logical bearings taken of so much of certitude as may remain. But, in doing this, it will be more convenient to consider both phases of the doctrine together, and only occasionally will the distinction between designed and designless creation be recurred to.

Arguments Classified.

§ 15. The arguments legitimately urged in favor of evolution may be grouped into three classes: first, historical, or such as find bases in accomplished facts;

second, philosophical, or such as propound natural laws, the action of which is supposed to necessitate evolutionary processes; third, negative or the enumeration of facts and phenomena which are thought to be inexplicable upon any other hypothesis. Conversely, the arguments for creation by design are: first, historical, or such as show that design permeates the phenomena of nature; second, philosophical, or such as elucidate laws imbedded in design; third, negative or such as present phenomena not otherwise explainable. It will be observed, however, that this classification distinguishes neither between designed and designless evolution in the one case, nor between creation by designed evolution and by any other designed process in the other case. Therefore, the arguments for evolution do not necessarily tend to disprove the existence of a personal Deity, while on the other hand, the arguments in favor of a designed creation have equal value, precisely, in favor of a designing Creator.

Systems of Evolution.

§ 16. Discussing principally and in the first instance, the philosophical evidences of evolution, four more or less distinct systems are prominently presented for investigation. The first in the order in which it is found convenient to here examine them is Mr. Herbert Spencer's philosophy of evolution founded upon the doctrine of the persistence of force. The second is Mr. Charles Darwin's philosophy of natural selection, based upon casual variations and heredity. The third is M. Lamarck's theory of adaptation. The fourth is Prof. E. D. Cope's doctrine of bathmism or growth force. Of these systems, only Mr. Spencer's attempts a philosophy of evolution for inorganic nature; the others all commence with life. It is true, however, that other philosophers, notably, Dr. Bastian, Prof. Haeckel, and Mr. James Hinton, attempt to elucidate the genesis of life on evolutionary principles; and various other writers have propounded theories more or less profound of different phases of the general doctrines, but, so far as it may be deemed necessary to refer to them here, they can all be noticed in the discussion of the four systems above mentioned.

CHAPTER III.

SPENCER'S SYSTEM—ESTIMATION OF BY WRITERS—THE BASIS OF—PERSISTENCE OF FORCE—EXTRACTS FROM FIRST PRINCIPLES—LOGIC OF THE SYSTEM ATHEISTIC—THE CONCLUSIONS FOLLOW THE PREMISES.

Spencer's System.

§ 17. Mr. Spencer has levied tribute of all the other scientists of this and preceding ages. In particular has he gathered in the labors of the founders of the recent grand generalizations of conservation and evolution, of those profound and immortal thinkers, Kant and Laplace, Rumford and Davy, Mayer and Grove, Faraday and Tyndall, Darwin and Huxley, Helmholtz and Haeckel, Maxwell and Thompson, and their hosts of compeers almost equally distinguished; and with this wealth of research and discovery essayed to formulate a system of universal philosophy; a grand and worthy effort, indeed! And with extraordinary industry and fearless candor he has builded a system which offers to account for and explain every possible phenomenon, not only in physical nature, but in the mental, moral, social, political and religious worlds as well. But as the writer understands it, it is, unfortunately, a system without a hope of sentient immortality, without an immaterial human soul, and without a designing, directive Deity; though fortunately, since being such, builded, as he expects to show, upon the sands.

§ 18. That in evolutionary philosophy Mr. Spencer's authority is high, and his influence great, will appear from a few references. Thus Prof. Spaulding says of his system: "We cannot exhibit the grandeur; we can only in a few general phrases express our admiration of the profound all-embracing philosophy of which the work before us is an installment. The doctrine of evolution, when taken up by Mr. Spencer, was little more than a crotchet. He has made it the idea of the age. In its presence other systems of philosophy are hushed; they cease their strife and become its servants, while all the sciences do it homage."

The distinguished astronomer, Richard A. Proctor, lately deceased, said: "Herbert Spencer I esteem, I may almost say I reverence as the teacher of the soundest system of philosophy the world has yet, in my judgment, known." Again he calls Mr. Spencer "the leading philosopher of the century," "the Bacon of this day," and speaks "of the school of which Spencer has been the Bacon, the Darwin and the Newton." *Pop. Sci. Month.* Apr., 1884, *pp.* 843, 844.

Basis of Spencer's System.

§ 19. Mr. Spencer bases his whole system upon and builds it up out of a single physical doctrine, and not only admits, but insists that it must stand or fall with that doctrine. The doctrine referred to is that of the "Persistence of Force," otherwise called "Conservation of Energy" or "Correlation of Forces. That Mr. Spencer is correctly represented will clearly appear from the following extracts:

"The sole truth which transcends experience by underlying it, is thus the Persistence of Force. This being the basis of experience must be the basis of any scientific organization of experiences. To this an ultimate analysis brings us down, and on this a rational synthesis must be built up." *First Principles*, p. 192, *d.*

"From the specification of this we passed to certain primary truths—'the Indestructibility of Matter,' 'the Continuity of Motion,' and 'the Persistence of Force:' of which the last is ultimate, and the others derivative. Having previously seen that our experiences of Matter and Motion are resolvable into experiences of Force, we further saw the truths that Matter and Motion are unchangeable in quantity, to be implications of the truth that Force is unchangeable in quantity. This, we discovered, is the truth by derivation from which all other truths are to be proved.

"The first of the truths which presented itself to be so proved, was 'The Persistence of the Relations among Forces.' This, which is ordinarily called Uniformity of Law, we found to be a necessary implication of the facts that force can neither arise out of nothing nor lapse into nothing.

"The deduction next drawn was that the forces which seem to be lost are transformed into their equivalents of other forces; or, conversely, that forces which become manifest, do so by disappearance of pre-existing equivalent forces. Of these truths we found illustrations in the motions of the heavenly bodies, in the changes going on over the Earth's surface, and in all organic and super-organic actions.

"It turned out to be the same with the law that everything moved along the lines of the least resistance, or the line of the greatest traction or the resultant. Among movements of all orders, from those of stars down to those of nervous discharges and commercial currents, it was shown both that this is so, and that, given the Persistence of Force, it must be so.

"So, too, we saw it to be with 'The Rhythm of Motion.' All motion alternates—be it the motion of planets in their orbits, or ethereal molecules in their undulations—be it the cadences of speech or the rises and falls of prices; and as before, it became manifest that, force being persistent, this perpetual reversal of motion between limits is inevitable."—*Ibid*, 539.

"We might indeed be certain, even in the absence of any such analysis as the foregoing, that there must exist some principle which, as being the basis of science, cannot be established by science. All reasoned-out conclusions whatever must rest on some postulate. As before shown, we cannot go on merging derivative truths into those wider and wider truths from which they are derived, without reaching at last a widest truth which can be merged in no other or derived from no other. And whoever contemplates the relation in which it stands to the truths of science in general will see that this truth transcending demonstration is the persistence of force."—*Ibid*, 192, *c*.

"In other words, the phenomena of Evolution have to be deduced from the Persistence of Force." —*Ibid*, 398.

§ 20. From these extracts it is clear that not only does Mr. Spencer bottom his philosophy of the processes of evolution upon the doctrine of the persistence of force, but the causes and laws of evolution as well. All things come to be and are, solely by reason of one great inevitable principle out of which, because of its necessary constitution emanates, not only all other principles but also all causes, all action, and all laws. He leaves, therefore, no room for volition or personality. Practically, if not theoretically, he banishes all other cause, including Deity from the universe, for it amounts to nothing to claim, as Mr. Spencer does, that there is a great Unknown and Unknowable Power behind the knowable, if within the knowable, there be an all-sufficient cause for the knowable as well as for the laws by and through which it acts. If in the force and matter of the universe, all its motion, fact, and form, together with the determining conditions of all its activities, are contained; or, in other words, if it possesses within itself all the elements, instrumentalities, and means of running itself, it would seem to be a matter of the most profound indifference to all the interests centered in its affairs, whether or not there be outside of it, and to which it owes no dependence, a great Unknown and Unknowable Power. To quote the language of the New York *Independent*, replying to Dr. McCosh's defense of evolution in the columns of that paper: "It postulates a God at the beginning of the development, but rules Him out of the field forever afterward. It sets God so high up and puts Him so far off that He is of no practical use as a personal helper for a struggling and despairing world."

The Unknowable.

§ 21. Mr. Spencer bases his system wholly upon conservation, and this means that no new force has ever come into action in the physical universe, but, on the contrary, that from the very beginning of things the existent forces in the physical or visible universe had the necessary potency to produce all the outcome of nature and all the potency they ever should have. Now if, as Mr. Spencer claims, there be "a great Unknowable Power concealed behind the changing course of phenomena," one of two alternatives is inevitable, either such Unknowable does or does not interfere with the course of phenomena; if it does it can only be by, in some way, adding to or subtracting from the potency of the forces at work in the universe; in some way, influencing, controlling, or adjusting these forces so as to cause them to do more or less than they otherwise would have done, or to act in a manner different from what they otherwise would have done. But this is contrary to the theory of conservation, so much so, indeed, that if it be true the theory necessarily fails. I understand Mr. Spencer to dissent from this proposition that nature's forces are helped out in any way or to any degree from the Unknowable. "If there has been that special formation or adjustment commonly meant by creation, there has been no evolution."

On the other hand, if there is and has been no such interference or control, any such Unknowable, if such there be, is as though it were not so far as the condition of knowable nature is concerned. And not only so, but without some such connection as will amount to more or less interference or control, if there be any such Unknowable it will be forever impossible for us ever to be cognizant of the fact. It can never be anything more to us than a myth or a dream.

True, Mr. Spencer speaks of the "Unknowable as the power that manifests itself at the same time in the universe and in the consciousness, as the Supreme Reality," of "an Infinite and Eternal Energy from which all things proceed," of "the laws which reason discovers in the moral as well as in the physical world as modes of the Unknowable," of "the laws of nature being the modes of action of the Unknowable," and of the knowable being but a symbol of the Unknowable;" but, nevertheless, the argument stands: if he means by these expressions that any virtue or potency of any kind, character, or degree passes from the Unknowable to the knowable that is the end of the doctrine of conservation.

But if he does not mean this, then he must mean the contrary, for there is no middle ground, and the above expressions, together with many others he has used, become quite misleading.

Although Mr. Spencer says: "Everywhere I have spoken of the Unknowable as the ultimate reality—the sole existence: all things present to consciousness being but shows of it;" yet conservation, if it be true in the sense assumed by Mr. Spencer, constitutes a high wall shutting off all correspondence, all influence, all potency, all virtue, from the Unknowable, and when he would take down that wall to let in such influences and potencies he will necessarily find it is conservation he is razing; but his own system is builded upon conservation and will therefore crumble with it. Logically, therefore, there is a great gulf and a high wall between, and no way for "that Infinite and Eternal Energy out of which humanity has quite recently emerged, and into which it must, in course of time, subside," to reach us or for us to reach it save by breaching the wall and bridging the gulf with the *débris*.

Indeed the effort of Mr. Spencer and his disciples seems to be to find a middle-ground where there is none, a practicable footing between personality and no personality, between interference and no interference, control and no control, Deity and no Deity, and in this effort, they attempt to lean upon conservation for support; but for the moment, conceding the verity of that doctrine, it cuts the last vestige of ground from under their feet. It says there is no middle-ground, but all clean-cut, closely-shaven non-interference, absolute and necessary indifference to all extraneous sources and powers.

Logic of Spencer's System.

But, granting Mr. Spencer's premises, that his conclusions are logically just there can be no question. If all force persists and there be neither increase nor diminution (including in the term thought and mind, as Mr. Spencer does), then, out of the very fact of persistence arise the laws of "persistence of relations," "transformation," "motion in the lines of least resistance or greatest traction" and "rhythm;" these laws govern all the motion in nature and determine all material form and organic existence, and, therefore, there is neither place nor room for the control, direction or interference of any outside power. Starting with any epoch in past eternity, if the visible forces then existent have sufficiency within themselves to build all the future of the material universe, conservation must be true, and there is no need, nor place for an exterior power to instil or pour into nature any potency whatever. But if, on the contrary, at any such epoch, the then existent forces in nature, were in any manner, degree or character inadequate, in and of themselves, to evolve the universe and frame and clothe all nature as we find it, including life and thought and feeling and mind, it results of a necessity, that the deficiency must have been made good by supplies of virtue from some extraneous source, and therefore that extraneous source of power, whatever called or wherever found, became a necessity in the building of nature; and at every point and every moment of time where such necessity was manifested, conservation was discredited and refuted.

Hence it will be patent to the most casual thought that Mr. Spencer's system has a significance far more profound than simply that of furnishing a basis for one theory of Evolution; for, whether regard be had to the inestimable value of abstract philosophical truth, or whether one is concerned about the substantial supports to doctrines of faith which afford the surest solace and strength in the struggles of the present life, and the only hope of lengthening out this slender thread of conscious existence beyond the catastrophe of physical dissolution, the value of the basis of Mr. Spencer's magnificent argument presents a question of as stupendous interest as is possible of being framed by the language or thought of man.

CHAPTER IV.

PERSISTENCE OF FORCE—ENCOMIUMS UPON BY SCIENTISTS—SCOPE OF—READY ACCEPTANCE OF—DEFINITION OF—BY GROVE, HELMHOLTZ, MERRIMAN, CARPENTER, GRANT ALLEN, POINIER,—THE OTHER SIDE.

Persistence of Force.

§ 22. OF course, therefore, it becomes necessary in the very outset of the investigation to examine critically and exhaustively the doctrine of Persistence, and ascertain, if we may, its general scope and degree of certitude ; for, if Mr. Spencer's interpretations be correct, it is grander in its claims and broader in its sweep than even that corner stone of nature contributed by the matchless genius of Sir Isaac Newton to the domain of science, and quite as potent in fixing the meaning of the universe. And Mr. Spencer is not alone in assigning to Persistence this transcendent importance.

Prof. Codling calls it: The grandest generalization in science that has ever yet been established." Prof. Merriman says of it: "The greatest triumph of modern science is the splendid induction that all the forces are correlative and indestructible." Prof. Faraday calls it: "The highest law in physical science which our faculties permit us to perceive." Prof. Steele speaks of it as: "The grandest law nature offers for the contemplation of the human mind." Prof. Iles says: "Evolution is underlaid as is all change by the greater law of the persistence of force." Wm. Lant Carpenter says: "Properly regarded in its various aspects, it is one of the most sublime generalizations of modern times; the most sublime phenomena of the universe are seen to happen in accordance with it, while the life and movements of the minutest living being, and the most insignificant natural phenomena occurring in human experience, alike bear witness to its truth."

Prof. Tyndall says: "In our own day great generalizations have been reached. The theory of the origin of species is but one of them. Another of still wider grasp and more radical significance is the doctrine of the conservation of energy, the ultimate philosophical issues of which are as yet but dimly seen—that doctrine which 'binds nature fast in fate,' to an extent not hitherto recognized, exacting from every antecedent its equivalent consequent, from every consequent its equivalent antecedent, and bringing vital as well as physical phenomena under the dominion of that law of causal connection, which, as far as the human understanding has yet pierced, asserts itself everywhere in nature. Long in advance of all definite experiment upon the subject the constancy and indestructibility of matter had been affirmed, and all subsequent experience justified the affirmation. Later researches extended the attribute of indestructibility to force. This idea applied in the first instance to inorganic, rapidly embraced organic nature."

Again: "Quite fit to take rank with the principle of gravitation—more momentous if that be possible—is that law of conservation which combines the energies of the material universe into an organic whole; that law which enables the eye of science to follow the flying shuttle of the Universal Power as it weaves what the 'Earth Spirit' in Faust calls the living garment of God." *P. S. M., Sept.*, 1887, *P.* 660.

Dr. Youmans sketches "the stupendous reach" of the law in the following eloquent language: "It might well have been proclaimed the highest law of *all* science—the most far-reaching principle that adventuring reason has discovered in the universe. Its stupendous reach expands all orders of existence. Not only does it govern the movements of the heavenly bodies, but it presides over the genesis of the constellations; not only does it control those radiant floods of power which fill the eternal spaces, bathing, warming, illumining and vivifying our planet, but it rules the actions and relations of men, and regulates the march of terrestrial affairs. Nor is its dominion limited to physical phenomena: it prevails equally in the world of mind, controlling all the processes of thought and feeling. The star-suns of the remoter galaxies dart their radiations across the universe; and although the distances are so profound that hundreds of centuries may have been required to traverse them, the impulses of force enter the eye, and impressing an atomic change upon the nerve, gives origin to the sense of sight. Star and nerve tissue are parts of the same system—stellar and nervous forces are co-related. Nay, more : sensation awakens thought and kindles emotion, so that this wondrous dynamic chain binds into living unity the realms of matter and mind through measureless amplitudes of space and time."

Grant Allen says of it:

"The practical applications of the doctrine of energy are as yet only in their infancy. The whole mass of theoretical science has to be re-written in accordance with this new and fundamental law. The whole field of applied science has to be developed and enlarged by the light of this pregnant and universal principle. Its implications are all-pervading. In astronomy it has profoundly affected all our conceptions as to the sun's heat, the orbits of planets, the nature of meteors, the past, present, and future of the universe. In biology it has taught us to envisage the plant mainly as a machine in which kinetic energy is being transformed into potential; the animal mainly as a machine in which potential energy is being transformed back again into kinetic. In mechanics and the mechanical arts it has produced and is producing immense changes. And in the future it is destined still more profoundly to alter our mechanical ideas and activities : the great revolution there is only just beginning. Another brave century is needed yet to develop it." *P. S. M.*, *Oct.*, 1887 *p.* 511.

§ 23. And these learned men do not over-estimate the profound importance of the doctrine ; for it not only underlies, modifies, and determines the scope, value, and certitude of all science, both physical and metaphysical, but of all religious faiths as well. Insofar, therefore, as it may be true, it is not only one of the grandest, but one of the most vital, of all truths ; and, on the contrary, if, in any respect, erroneous, it is, insofar, the most dangerous of all errors.

Ready Acceptance of the Doctrine.

§ 24. It is a remarkable fact that, from the day of its formal promulgation by Mayer and Grove, the doctrine of conservation has been treated with a tenderness and partiality accorded to no other important scientific theory of modern times. As Prof. Tyndall remarks: "It slid quietly into acceptance." Instead of hesitating, doubting, scrutinizing, and investigating, scientists seem to have been captivated, if not blinded, by the magnitude and grandeur of the thought, and to have joined in a race, not of criticising, testing, weighing, and reasoning, but of piling up argument to support and demonstrate the hypothesis; so that, almost from the very beginning of the discussion, it has settled down in the scientific, as well as in the popular mind, upon a basis quite as solid and stable as the doctrine of gravitation itself.

Persistence Defined.

§ 25. The doctrine of conservation as at first propounded by Mayer and Grove includes the following four propositions:

No old force is ever lost.

No new force is ever generated.

The quantity of all the force in the universe remains constant.

The different forms of force severally metamorphose into each other.

Prof. Tait says: "The grand principle of conservation of energy, which asserts that no portion of energy can be put out of existence and no amount of energy be brought into existence by any process at our command, is simply a statement of the invariability of the quantity of energy in the universe,—a companion statement to that of the invariability of the quantity of matter."—*Recent Advances in Physical Science, p.* 17.

Prof. Grove says: "Now the view which I venture to submit is that force cannot be annihilated, but is merely subdivided or altered in direction or character."—*Correlation of Physical Forces, p.* 27.

Prof. Helmholtz says: "We arrive at the conclusion that nature, as a whole, possesses a store of force which cannot in any way be increased or diminished, and that, therefore, the quantity of force in nature is just as eternal and unalterable as the quantity of matter."—*Interaction of Natural Forces.*

Prof. Merriman says: "Not an impulse of motion, of light, or heat, or any force is ever lost. It may be communicated from one body to another, or transformed into some other form of force, or become for a time latent or imperceptible; but it always exists, and is reclaimable back again into the same, in mode and quantity from which it started."

Wm. Lant Carpenter says: "A grand thought which follows from the recognition of the indestructibility of energy is, that the total quantity of it in the universe is unchangeable, and can neither be increased nor diminished."—*Energy in Nature, p.* 14.

Grant Allen says: "Starting from this settled point, it soon became clear to physical thinkers that every species of energy was more or less readily convertible into every other, and that an exact numerical equivalence existed between them. * * * * * At last, under the hands of Clausius, Helmholtz, Mayer. Clerk-Maxwell, Tait and Balfour Stewart, the doctrine assumed its modern form—that all energies are mutually convertible, and that the sum total of energy, potential and kinetic, is a constant quantity throughout the cosmos."—*Pop. Sci. Month., Aug.,* 1887, *p.* 511.

Mr. Porter Poinier says: "The proposition that the entire energy existing in the universe is a magnitude as definite and unchangeable, as the quantity of matter which it contains is now considered one of the most fundamental and far-reaching in natural philosophy."

§ 26. From these various observations may be extracted the following expression for the notion of force entertained: Force is uncreated, underived, eternal, uniform in quantity, neither coming into nor passing out of the cosmos, but continually changing from one form or mode of existence into another according to inherent and necessary laws governing its constitution and character. And this is but an amplification of the four characteristics of conservation given above.

The Other Side.

§ 27. Before proceeding with this side of the argument, it would seem to be appropriate to take a hasty glance at what can be said in favor of THE OTHER SIDE of the great question.

"*These advances come or not according as we remember or forget that our science is to be based entirely upon experiment or mathematical deductions from experiment.*"—*Prof. P. G. Tait, Recent Advances in Physical Science, p.* 6.

With the above admonition in mind we not only may but *must* expect, that in examining the great doctrine of conservation, now universally accepted by all scientists as absolutely true, we shall find that every one of the four propositions of the doctrine are buttressed on the most extensive and exhaustive series of experiments and observations. Were we disposed to be over severe and critical, we might call for the history, genealogy or abstract of the various natural forces, to see whether it is true that no old force has ever been lost and no new force ever found; but in consideration of the fact that the time, or rather the eternity through which they have been active is long, we waive all that and will content us with what, of course, the scientists are prepared to exhibit, to wit: a reasonably full list of experiments, showing that each one of the four propositions has been found applicable to every one of the several modes of physical force, and that in no instance has the contrary been found true of any one of them. If Prof. Tait's apothegm is to be accepted, and all scientists insist on the importance and necessity of experiment about as strongly as he, they cannot afford to offer less.

§ 28. Therefore, we may expect to find from experiments made that no ray of heat or light radiated into the measureless depths of space from sun or star or world is lost, but that, on the contrary, it is all brought back and utilized in the material universe. But has any such experiments ever, in fact, been made? Of course not, nor any fact observed from which such a process can be logically inferred. Indeed, there can scarcely be a proposition named regarding which there is less ground in observation or experiment to base an opinion upon either one way or another. So far as our knowledge extends or as we have any right to express an opinion, the light and heat radiated into space are irrecoverably lost to the material universe.

§ 29. Again, has any scientist ever traced gravity down to the earth's center and discovered what has become of it so as to be able to say it is not lost—annihilated? Certainly not, and on that subject the ignorance of science is as profound as the very depths to which gravity is continually passing, as pressure-force,—so far as they know or dare say, it is lost. If these scientists are not prepared to say from experiment nor observation that the great forces of heat, light, and gravity, are not, in certain instances, lost, of which of the forces are they prepared to say it? Have they demonstrated that when quartz, or glass, or pottery are ground to powder, cohesion is not lost? Do they know that in no instance is elasticity or capillary ever lost? Have they examined these forces on every side and at every point, and obtained so thorough a knowledge of them as to be able to say with certainty that they persist under all conditions?

On the contrary, are they not profoundly ignorant concerning them? And what more do they know about chemism crystallization, electricity or magnetism? Can they be absolutely certain that when the crystal is crushed or the artificial magnet loses its power, no force is ever lost? Prof. John Trowbridge says of electricity: "After I have concluded, you will probably ask yourselves, 'What is electricity?' All I can hope to do is to make you ask yourselves with more humility, and a greater consciousness of ignorance—for the ignorant man, I have found, is generally sure that he knows what electricity is; and, the more learned a person is the more he is convinced that he does not know what electricity is."—*P. S. M., Nov.*, 1884, *p.* 76.

Again: "In thus looking for the seat and origin of electrical action, how much have we discovered? It is evident that our knowledge of electricity will increase with our knowledge of molecular action, and our knowledge of molecular action with that which we call attractive force. It is somewhat strange that although we are so curious in regard to electricity, we seldom reflect that gravitation is as great a mystery as electrical attraction. What is this force which acts instantly through space, and which holds our entire solar system together? We know only its simple law—that it attracts bodies directly as their masses and inversely as the square of their distance; but we do not know what relation it bears to electrical force or magnetic force. Here is a field in which we are to push back our boundary of electrical knowledge.—I will not call it electrical knowledge, but rather our knowledge of the great doctrine of the conservation of energy. What is the relation between electricity, magnetism and gravitation, and what we call the chemical force of attraction? It seems to me this is the question we must strive to answer; but, when this question is answered, shall we not be as far as ever from the answer to the question, 'What is electricity?'"—*Ibid*, *p.* 82.

Now, with such confessed ignorance regarding these great forces, how can any assertion be safely made regarding their persistence?

§ 30. But passing to the next proposition: no new force is ever generated; where is the experiment, observation or fact showing or tending to show that when matter is brought nearer together by the condensation of gravitation, the force that grows up in it inversely as the squares of the distances is not a *new* force? The gravitative force in the particles of earth is many million times greater than it was when its matter was diffused beyond the orbit of the moon. What observed fact shows that none of this *grown up* force is new? How has it been shown that the force which crystallizes sugar or salt, or which holds together the particles of granite or brass, or unites the molecules of lime and carbonic dioxide to form calcic carbonate were old while yet the matter of the sugar and salt, the granite and brass, the lime and carbonic dioxide, were diffused elemental gases? How is it known that the elastic force in the rubber ball is older than all rubber or all vegetable products? or that there was magnetism before there was any earth to have a magnetic pole?

§ 31. And if all these facts are experimentally lacking to the full right to say that no forces are lost or found, how can the third proposition that the sum of all nature's forces are constant be known or consistently maintained?

§ 32. Now passing to the fourth proposition: which one of all the forces is it that passes into gravity? Or in other words, what was gravity before it became gravity? And what was the prior state of cohesion, or capillary, or elasticity, or chemism, or crystallization, or magnetism, or electricity? Can any one answer? Has any experiment ever shown? Certainly not. And what can it be claimed that any of these forces last named ever metamorphose except into kinetic or moving force, pressure-force, heat, light and electricity? Nothing else.

§ 33. Correlations are pretty clearly established *from* gravity to molar force and pressure-force; also from elasticity, crystallization, chemism and magnetism to the same; also *between* electricity on the one hand, and heat, light, magnetism and molar force on the other; also *between* molar force and pressure-force; and *between* molar force and heat and light. But there has never been any correlation shown *from* any other force *towards* gravity, cohesion, capillary, elasticity, crystallization or chemism. No observation shows that any one of these forces was ever anything else than what it is now; and there is nothing to show any correlation whatever of either cohesion or capillary with any other forces, either as antecedent or consequent terms; and, so far as any experiment has shown, in every case the correlation only goes to quantitative equivalence and coincidence in time and space. No experiment or observation has ever shown identity or sameness of essence. The most that can be claimed in any experiment is that at a particular time and place one force disappeared, and simultaneously an equal measure of another force appeared. So that the metamorphosis of one into the other is never anything more than an inference, a very strong inference sometimes, but immensely less so than it would be but for the fact that in every possible experiment there are always present at least six or eight forms of force, most of these very obscure and imperfectly known, and none of them perfectly understood, so that it is entirely possible in any experiment that the new force appearing may be a metamorphosis of one of the more obscure and unsuspected old forces spoken of, while the disappearing force may become latent, passed off in some other form, or dissipated. Certainly more attention should be paid to the less obtrusive forces present than has ever been done in any experiments yet made before it is safe to claim with absolute confidence a real metamorphosis of force, a true sameness of essence under different modes, in any instance.

§ 34. Then what have we for the strength of the argument on this *other side?* First, an absolute failure to show by experiment that any one of the several physical forces is never lost, that is, that the first proposition applies to any one of these forces. Second, a like failure to show that the second proposition applies to any of the forces. Third, a consequent failure to show that the third proposition applies to all or any one of them. Fourth, a partial correlation between the forces, that is a mutual correlation between some of them, a correlation in only one direction between others, and some of them wholly uncorrelated on one or both sides; and this partial correlation only numerical and of time and place, but not of essence at all, and, further, taking place in the presence of a number of obscure and almost unknown modes of force; and this partial correlation, under these *suspicious* circumstances, is all there is or was upon which to build the great system of conservation. Perhaps the human mind has never before reared an intellectual edifice so vast and imposing upon a foundation so fragile and insecure; and this has been done by the great *experimental* philosophers of the age, those who will tolerate nothing but *experiment* or mathematical reasoning founded upon *experiment.* Nevertheless the fact here is that they have set up a vast mechanism of theory pinioned at a few points with very small rivets and bands of fact, and then fallen down and worshipped it as the great Moloch of all science and all knowledge.

CHAPTER V.

FORCE AND ENERGY—DEFINITION BY WM. LANT CARPENTER—PROF. THURSTON—WM. B. TAYLOR—PROF. TAIT—STEWART AND TAIT—DR. CROCKER—PROF. GROVE—GRANT ALLEN—BALFOUR STEWART—JUDGE STALLO—HERBERT SPENCER—ANALYSIS OF CARPENTER'S DEFINITION—OF THURSTON'S—OF TAYLOR'S—OF TAIT'S—OF STEWART AND TAIT'S—OF ALLEN'S—OF BALFOUR STEWART'S—OF STALLO'S—OF SPENCER'S—EXAMINED AND COMPARED—CONTRADICTIONS—SPENCER'S NOTION OF FORCE AND ENERGY.

Force Defined.

§ 35. Having ascertained quite definitely what is meant or rather what *was* meant by "persistence of force" or conservation of "energy," the next thing in the discussion is to find out what is meant by the terms "force and energy;" in order that we may have clear notions about what it is that is supposed to persist, for, obviously, any discussion of a subject not clearly outlined in thought is futile. Doubtless the unscientific reader has, in his own mind, very clear conceptions of "force," if not of "energy" also, and could give us a very accurate definition of it. He will therefore, in all probability, be astonished when informed that in scientific literature it is the most obscure, vague and shadowy word in the language, so much so, indeed, that after wading through many pages of extracts trying to learn what it is that is understood by scientists to "persist," he will probably find in the end that no two of them agree with each other, and even that hardly any one of them agrees with himself throughout. Then why waste time and space over terms which nobody understands, or at least which no two understand alike? Because it is the " key to the situation." They all say " force persists," or " energy persists," and all pile up arguments in support of the proposition. Before we can weigh and test these arguments it is necessary that we should come, as nearly as possible, to an apprehension of what the arguments are intended to support, and to attain this end we have to do our utmost to grasp the notions of that force or energy which persists. Therefore, the views of several scientists will first be given and afterwards critically analyzed.

§ 36. Wm. Lant Carpenter says: Hitherto we have spoken of force, and of the forces of nature; and so long as heat, chemical attraction, electricity, magnetism, etc., etc., were regarded as so many distinct and separate forces (called in the older books on natural philosophy the " imponderables," *i.e.*, the unweighables), this phraseology served its purpose very well. As, however, the idea gradually became developed that these so called various forces were all different manifestations of *a power of doing work* (*i.e.*, causing change), residing in or acting through matter, the need was felt for some general phrase which should include them all; accordingly, the word *energy* was adopted, as expressing more accurately this fundamental idea. Energy, then, is the *power of doing work*, in the strict scientific sense of the term." —*Energy in Nature, p.* 3.

" Hence force may be defined as *that action upon a body, under which the state of rest of that body or its state of uniform motion in a straight line suffers change*."—*Ibid, p.* 4.

" It is evident, therefore, that force also can only be known by its effect upon matter, and that it is not a thing (in the ordinary sense of that word) any more than the bank-rate of interest is a sum of money, or a birth-rate of children is the actual group of children who are born in a year. Force is simply the expression of the rate of speed at which any change takes place in matter; what its essence or primordial cause is, is a problem that science does not attempt to solve.

"The terms energy and force do not, therefore, mean exactly the same thing, and, indeed, it is most important to grasp, and to bear in mind, the distinction between them. Energy involves two distinct ideas combined, whereas force involves only one. Energy has been defined as the power of doing work, and work is force exerted through the space, *i.e.*, that is the idea of motion of some kind is connected with it."— *Ibid*, *p.* 5.

"When a weight rests upon the ground, the weight pushes the ground down with a certain force, and the ground pushes the weight up with the same force. It is obvious, however, that a weight in this condition is incapable of doing any work, *i.e.*, of producing motion of any kind; indeed the very expression 'dead weight' applied to it is a practical admission of its inefficiency in this respect. The pressure that this inert weight produces is force and not energy. In every case in which force is said to act, what is really observed is a transference (or a tendency to transference) of energy from one portion of matter to another, and the so-called force in any direction is simply the rate of that transference."—*Ibid*, *p*. 5.

§ 37. Prof. Thurston says: "The grand principle which we are just beginning to admit and recognize as underlying every branch of knowledge, and as forming the foundation of all the sciences—of all science—seems, when stated, to be simply an axiom. The scriptural declaration that the universe shall endure forever is but a statement of the principle which is now becoming more and more generally admitted as a scientific truth, viz: That the two products of creation—matter and force and the fruit of their union—energy—are indestructible.

"The grand basis of all science is found, then, in the principle: All that has been created by Infinite Power—matter and its attribute, force, and all energy—is indestructible by finite power and shall continue to exist as long as the hand of the Creator is withheld from their destruction. * * * *

"Looking back to the beginning, we see, then, that in the beginning there entered upon an existence which is of indefinite duration a great universe of matter, endowed with its characterizing attributes—the forces of nature. These forces acting upon all matter gave birth to a fixed amount of actual energy, and are capable of producing another fixed quantity of what is now potential energy. Energy thus coming into existence remains constant in amount as the quantity of created matter remains constant.

"The action of these forces upon this matter has given rise to every phenomenon which has come or does now come within the range of scientific inquiry." —*Address at St. Louis meeting of Am. Asso. for Advancement of Science*, 1876.

§ 38. Mr. William B. Taylor says: "When a stone is thrown upward, therefore, it loses tension, because this *has been found empirically* to be the inflexible law of distance-ratio for the gravitation force, *and for no other human reason.* It gains in potential energy by the ascent, because there has been a corresponding expenditure of kinetic energy in effecting the ascent; and all experimental research proves the absolute constancy of the sum of these two forms of energy. And this constancy is all that is signified by the oft-quoted but not always justly apprehended 'conservation of force.' So far from there being any fixed relation between gravitative force and the production of motion, the ratio varies in every planet; and, while the height to which a pound of gunpowder would project a ball upward would differ widely in different planets, the velocity of projection and the returning energy of the fall would be precisely the same in all. Were we to rigorously deny that gravitation is energy, or that energy is force, we could not correctly affirm the conservation of 'force.' The thing truly conserved would be energy, and this is undoubtedly the more accurate and less misleading form of expression."—*Smithsonian Report*, 1876, *p*. 263.

"Properly speaking 'force' is not conserved at all! It is the *offspring* of 'force' or 'work' that is conserved * * * * with a strong suspicion that there is probably no such thing as force at all."—*Ibid*, *p*. 232.

§ 39. From Prof. Tait's work, "Recent Advances in Physical Science," the following extracts are made: "The definition of force in physical science is implicitly contained in Newton's first Law of Motion, and may thus be given:—

Force is any cause which alters or tends to alter a body's natural state of rest or of uniform motion in a straight line.

"The only difficulty, and it is a serious one, which we feel here, is as to the word 'cause;' for this, amongst material things, usually implies objective existence. Now we have absolutely no proof of the objective existence of force in the sense just explained. In every case in which force is said to act, what is really observed, independent of the muscular sense (whose indications like those of the sense of touch in matters concerning the temperature of bodies, are apt to be excessively misleading), is either a transference, or a tendency to transference, of what is called energy from one portion of matter to another. Whenever such a transference takes place, there is relative motion of the portions of matter concerned, and the so-called force in any direction is merely the rate of transference, or of transformation, of energy per unit of length for displacement in that direction. Force, then, has not necessarily objective reality any more than has velocity or has position. The idea, however, is still a very useful one, as it introduces a term which enables us to abbreviate statements which would otherwise be long and tedious; but as science advances, it is in all probability destined to be relegated to that limbo which has already received the crystal spheres of the planets, and the four elements, along with caloric and phlogiston, the electric fluid and the odic or psychic force.

"It is only, however, within comparatively recent years that it has been generally recognized that there is something else in the physical universe which possesses to the full as high a claim to objective reality as matter possesses, though it is by no means so tangible, and therefore the conception of it was much longer in forcing itself upon the human mind. The so-called imponderables—things of old supposed to be matter—such as heat and light, *et cetera*, are now known by the purely experimental and therefore the only safe, method to be but varieties of what we call energy,—something which though not matter, has as much claim to recognition on account of its objective existence as any portion of matter.—*p.* 16."

"Without further discussion we may state once for all, that our conviction of the objective reality of matter is based mainly upon the fact, *discovered solely by experiment*, that we cannot in the slightest degree alter its quantity. We cannot destroy, nor can we produce, even the smallest portion of matter. But reason requires us to be consistent in our logic: and thus, if we find anything else in the physical world whose quantity we cannot alter, we are bound to admit it to have objective reality as truly as matter has, however strongly our senses may predispose us against the concession. Heat, therefore, as well as light, sound, electric currents, etc., though not forms of matter, must be looked upon as being as real as matter, simply because they have been found to be forms of energy—which in all its constant mutations satisfies the test which we adopt as conclusive of the reality of matter. We shall find that this test fails when applied to force."—*p.* 346.

Again: "Newton says: '*If the action of an agent be measured by the product of its force into its velocity; and if, similarly, the reaction of the resistance be measured by the velocities of its several parts into their several forces, whether these arise from friction, cohesion, weight or acceleration;—action and reaction in all combinations of machines, will be equal and opposite.*'

"The actions and reaction which are here stated to be equal and opposite are no longer simple forces, but the products of forces into their velocities; *i.e.* they are what are now called *rates of doing work*; the time-rate of increase or the increase per second, of a very tangible and real SOMETHING, for the measurement of which Watt introduced the practical unit of a *horse-power*, the rate at which an agent works when it lifts 33,000 pounds one foot high per minute, against the earth's attraction.

"Now let the reader think of the difference between raising a hundredweight and endeavoring to raise a ton. With a moderate effort he can raise the hundredweight a few feet, *and in its descent it might be employed to drive machinery or do some other species of work.* Let him tug as he pleases at the ton, he will not be able to lift it; and, therefore, after all his exertion, it will not be capable of doing any work by descending again.

"In both cases the first interpretation of Newton's *Third Law* has been verified. With whatever force he pulled either of the masses, that mass reacted with an equal force. But the second interpretation cannot be applied to the ton; *for it did not acquire any velocity*, it was not moved. Hence, as no work was spent upon it, it has not acquired the power of doing work. On the other hand, the hundredweight was moved, work was done upon it, and the work was stored up in it in its raised position, ready for use at any future time. Newton's statement implies that in this case the work spent in raising the hundredweight is stored up (without change of amount) in the mass when raised.

"Thus it appears that *force* is a mere name; but that the *product of force into the displacement of the point of its application* has an objective existence. [Even those who are so metaphysical as not to see that the product of a *mere name* into a displacement can have an objective existence, may perhaps see that the quotient of a horse-power by a velocity is not likely to be more than a mere name.] In fact, modern science shows us that force is merely a convenient term employed for the present (very usefully) to shorten what would otherwise be cumbrous expressions; but it is not to be regarded as a thing any more than the bank rate of interest is to be looked upon as a sum of money, or than a birth-rate of a country is to be looked upon as the actual group of children born in a year."—*Heat, p.* 13.

"Following a hint given by Young, we now employ the term ENERGY to signify the power of doing work, in *whatever* that power may consist. The raised mass, then, we say, possesses in virtue of its elevation an amount of energy precisely equal to the work spent in raising it. This dormant, or passive, form is called *potential* energy. Excellent instances of potential energy are supplied by water at a high level, or with a head as it is technically called, in virtue of which it can in its descent drive machinery;—by the wound-up weights of a clock, which in their descent keep it going for a week;—by gunpowder, the chemical affinities of whose constituents are called into play by a spark, etc. etc."—*Ibid, p.* 16.

"Motion is simply a change of position; and force is recognized as the agent in every change of motion." —*North Brit. Review Vol.,* 56, *p.* 531.

§ 40. Stewart and Tait say: "Force proper is a pull, a push, weight, pressure, etc., and can be measured in the vernacular of engineers as equivalent to so many pounds' weight; but the unjustifiable use of the word applies it to *work done by a force*, so many pounds raised so many feet, *i.e., force overcome* *through a space.* Two such things are of different kinds, and cannot possibly be compared together. They differ in fact precisely in the same way as length and breadth differ from superficial area, *i.e.*, as a lineal foot differs from a square foot! And the modern abuse of the word is more outrageous, alike to science and to common sense, than would be the attempt to assign the height of a mountain in acres! For the absurdity does not end even here. We have, as yet, absolutely no proof whatever that force proper has an objective existence. In all probability there is no such thing as force."—*Unseen Universe*, *p.* 104.

" *Vis viva* is the old name for energy of motion or the consequent power of doing work."—*Ibid*, *p.* 107.

" Now when at the top of the cliff the ball had not the energy due to actual motion, it had nevertheless some sort of energy due to its elevated position for it had obviously the power of doing work. * * * *We thus recognize two forms of energy which change into one another, the one due to actual motion and the other to position; the former of these is generally called kinetic, and the latter potential energy.*"—*Ibid*, *p.* 109.

" In other words while the one form of energy becomes changed into the other,—potential into kinetic and kinetic into potential; or one species of either into another, yet each change represents at once a creation of one kind of energy and an equal annihilation of another, the total energy present, as we have broadly said, remaining forever unaltered.

" Taking as one system of bodies the whole physical universe, we now see that, according to the test we have already laid down, energy has as much claim to be regarded as an objective reality as matter itself." —*Ibid*, *p.* 114.

" In fact, if we think for a moment over what has just been said, to the effect that the only real things in the physical universe are matter and energy, and of these matter is simply passive, it is obvious that all the physical changes which take place, including those which are inseparably associated with the thoughts as well as the actions of living beings are merely transformations of energy." *Ibid*, *p.* 116.

§ 41. Dr. Crocker says: "A more precise and accurate statement would require that the term 'energy' should be substituted for 'force.' In the language of modern physics, *force* is that which originates or tends to originate motion or change, and is *wholly expended* in the action it produces.' All energy has its origin in force, but force cannot pass into energy except under conditions in which it is at liberty to act. For instance the *force* of gravity produces the *energy* of motion of a falling body, but gravity cannot produce motion unless there is space through which a body can fall. *Energy*, therefore, is defined as the power of doing work. The work done is the resistance overcome, and in overcoming resistance the energy is transformed but not annihilated." *Theistic Conception of the World*, *p.* 202.

§ 42. Grant Allen says: "A FORCE is a power which initiates or accelerates aggregative motion, while it resists or retards separative motion, in two or more particles of ponderable matter (and possibly also of the ethereal medium.")—*Force and Energy*, *p.* 5.

"An energy is a power which resists or retards aggregative motion, while it initiates or accelerates separative motion, in two or more particles of ponderable matter or of the ethereal medium."—*Ibid*, p. 7.

§ 43. Balfour Stewart says: "Let us now take a group of bodies at rest with regard to one another: this state of rest can only be changed by force. Thus, for instance, suppose we fire a gun, the previous state of rest of the bullet has now been changed by the force of the gun-powder into one of rapid motion. Or take a railway train at rest: the train is set into rapid motion through the force derived from the engine which draws it.

" But as it needs force to produce motion, so does it equally need force to destroy it; the bullet from the gun will ultimately have its motion destroyed by the resistance from some hard substance against which it strikes, and the railway train will have its motion stopped by the friction caused by the break. A thing which is difficult to move is difficult to stop, and a thing which is easy to move is easy to stop, the reason being that it requires an equal and opposite application of force to set a body in motion and to bring it again to rest."—*Elementary Physics, p.* 7.

" Force does not, however, always produce motion. Thus a stone, lodged on the top of a precipice, is not in motion, although in virtue of the force of gravitation of the earth it presses or weighs upon the ground of the cliff. But this same force which causes the pressure of the stone against its support, will cause it to fall downwards over the side of the cliff, with a continually increasing velocity, when once the support is removed, and it is free to obey the attraction of the earth."—*Ibid, p.* 8.

" If we define energy to mean the power of doing work, it thus appears that a stone shot upwards with great velocity may be said to have in it a great deal of actual energy."—*Ibid, p.* 103.

" It thus appears that when a stone which has been projected upwards, has been caught at the summit of its flight, and lodged on the top of a house, the energy of actual motion with which it started has been changed into another form of energy, which we denominate Energy of Position or Potential Energy, and that by allowing the stone again to fall we may change this energy of position once more into actual energy, so that the stone will reach the ground with a velocity, and hence with an energy, equal precisely to that with which it was originally projected upwards."—*Ibid, p.* 104.

§ 44. Prof. Grove defines force as "that which produces or resists motion."

§ 45. Judge Stallo says: "The antagonism thus presented," by the corpuscular and dynamic theories, "is utterly baseless. Matter can no more be realized or conceived as mere passive, spatial presence, than as a concretion of forces. Force is nothing without mass, and mass is nothing without force. Just as the metaphysician cannot conceive the 'thing' or substance apart from its properties, or, conversely, the properties apart from the substance, so the physicist cannot grasp matter (*i.e.*, mass) without force, or force without matter. Mass inertia or matter *per se*, is indistinguishable from absolute nothingness; for mass reveals its presence or evinces its reality only by its action, its balanced or unbalanced force, its tension or motion. And, on the other hand, pure force is equally nothing; for if we reduce the mass upon which a given force, however small, acts, to its limit, zero—or, mathematically expressed, until it becomes infinitely small—the consequence is that the velocity of the resulting motion is infinitely great, and that the 'thing' (if under these circumstances we may still speak of a thing) is at any given moment neither here nor there, but everywhere—that there is no real presence. It is impossible, therefore, to construct matter by a synthesis of forces. And it is incorrect to say, with Bain, that 'matter, force, and inertia, are the three names for substantially the same fact,' or, that 'force and matter are not two things, but one thing,' or, that 'force, inertia, momentum, matter, are all but one fact,' the truth being that force and inertia are conceptual integrants of matter, and neither is in any proper sense a fact. *Modern Physics*, *p.* 161.

'The radical fallacy of the corpuscular as well as the dynamical theory consists in the delusion that the conceptual elements of matter can be grasped as separate and real entities. The corpuscular theorists take the element of *inertia* and treat it as real by itself, while Boscovich, Faraday, and all those who define atoms or molecules as 'centers of force,' seek to realize the corresponding element, *force*, as an entity by itself. In both cases products of abstraction are taken for kinds of reality."—*Ibid*, 162.

"The prevailing errors respecting the inertia of matter have naturally led to corresponding delusions as to the nature of force. Here we are met, *in limine*, by an ambiguity in the meaning of the term force in physics and mechanics. When we speak of a 'force of nature,' we use the word force in a sense very different from that which it bears in mechanics. A 'force of nature,' is a survival of ontological speculation; in common phraseology the term stands for a distinct and real entity. But, as a determinate mechanical function, force is simply the rate of change of momentum—mathematically expressed, the differential of momentum at a given instant of time. 'Momentum,' says Mr. Tait, 'is the time-integral of force, because force is the rate of the change of momentum.' In the canonical text-books on physics, force is defined as the cause of motion. 'Any cause,' says Whewell, 'which moves or tends to move a body, or which changes or tends to change its motion, is called force.' So Clerk-Maxwell: 'Force is whatever changes or tends to change the motion of a body by altering either its direction or its magnitude. Far greater insight into the nature of force is exhibited in the definition of Somoff, though the word 'cause' is retained: 'A material point is moved by the presence of matter without it. This action of extraneous matter is attributed to a cause which is named force.' Taking these definitions as correctly representing the received theories of physical science, it is manifest, irrespective of the considerations I have presented in this and the preceding chapters, that force is not an individual thing or entity that presents itself directly to observation or to thought, but that, so far as it is treated as a definite and unital term in the operations of thought, it is purely an incident to the conception of the interdependence of moving masses. The cause of motion or of the change of motion, in a body, is the condition or group of conditions upon which the motion depends; and this condition or group of conditions is always a corresponding motion or change of motion, of the bodies outside of the body in question which are its dynamical correlates. Otherwise expressed, force is a mere inference from the motion itself under the universal conditions of reality, and its measure and determination lie solely in the effect for which it is postulated as a cause; it has no other existence. The only reality of force and its action is the correspondence between physical phenomena in conformity with the principle of the essential relativity of all forms of physical existence.

"That force has no independent reality is so plain and obvious that it has been proposed by some thinkers to abolish the term *force*, like the term *cause*, altogether."—*Concepts of Modern Physics*, *p.* 166.

"Physicists generally, however, are in still greater confusion as to the nature of force in another aspect. Bodies are said to be *endowed* with a definite quantity of force; it is assumed that to every particular body or atom belongs, or that in such body or atom is inherent, an invariable measure of energy. This statement, besides involving the conceit just noted of the independent reality of force, implies the assumption that force can be an attribute or concomitant of a single particle, as such, ignoring the fact, which is otherwise well known to physicists, that the very conception of force depends upon the relation of two terms at least. 'Force,' says Clerk-Maxwell, "is but one aspect of the mutual action between two bodies which is called by Newton 'action' and 'reaction,' and which is now briefly expressed by the single word 'stress.' And in another place: 'If we take into account the whole phenomenon of the action between two portions of matter, we call it stress. . . But if we confine ourselves to one of the portions of matter, we see, as it were, only one side of the transaction—namely, that which affects the portion of matter under our consideration—and we call this aspect of the phenomenon, with reference to its effect, an external force acting on that portion of matter, and with reference to its cause we call it the action of the other portion of matter. The opposite aspect of the stress is called the reaction on the other portion of matter.' To the same effect is the statement of Rankine: 'Force is an action between two bodies, either causing or tending to cause change in their relative rest or motion.' It follows that a 'constant central force,' as belonging to an individual atom or molecule in and by itself, is an impossibility."—*Ibid*, 169.

"The truth is that neither mass nor motion are substantially real, but both are concepts, or, rather, constituents of a concept—the concept of matter." —*Ibid*, 149.

"That all attempts to construct physical phenomena by a synthesis of hypostasized conceptual elements, under the first or synthetical view, are futile, in physics no less than in metaphysics, is now sufficiently evident upon considerations variously presented. Whether these elements be *substance* and *accident*, or *matter* and *force*, they are equally unreal, and no reality can be produced by their conjunction." *Ibid*, 157.

"A body cannot survive the system of relations in which alone it has its being; its *presence* or *position* in space is no more possible without reference to other bodies than its *change of position or presence* is possible without such reference. As has been abundantly shown, all properties of a body which constitute the elements of its distinguishable presence in space are in their nature relations, and imply terms beyond the body itself."—*Ibid*, 200.

"It follows, of course, from the essential relativity of rest and motion, that the old ontological disjunction between them falls, and that in a double sense rest differs from motion, in the language of Euler, 'as one motion differs from another,' or, as modern mathematicians and physicists express it, that 'rest is but a special case of motion.' And it follows, furthermore, that rest is not the logically or cosmologically *primum* of material existence—that it is not the natural and original state of the universe which requires no explanation while its motion, or that of its parts, is to be accounted for. What requires, and is susceptible of, explanation is always a change from, a given state of relative rest or motion of a finite, material system; and the explanation always consists in the exhibition of an equivalent change in another material system. The question respecting the origin of motion in the universe as a whole, therefore, admits of no answer, because it is a question without intelligible meaning."—*Ibid*, 203.

"Nevertheless, it is of the greatest moment in all speculations concerning the interdependence of physical phenomena, never to lose sight of the fact that force is purely a conceptual term, and that it is not a distinct, tangible or intangible thing." *Ibid*, *p.* 167.

§ 46. Mr. Spencer says on page 169 First Principles: "We come down then, finally, to Force, as the ultimate of ultimates. Though Space, Time, Matter, and Motion, are apparently all necessary data of intelligence, yet a psychological analysis (here indicated only in rude outline) shows us that these are either built up of, or abstracted from, experiences of Force. Matter and Motion, as we know them, are differently conditioned manifestations of Force. Space and Time, as we know them, are disclosed along with these different manifestations of Force as the conditions under which they are presented. Matter and Motion are concretes built up from the *contents* of various mental relations; while space and time are abstracts of the *forms* of these various relations. Deeper down than these, however, are the primordial experiences of Force, which, as occurring in consciousness in different combinations, supply at once the materials whence the forms of relations are generalized, and the related objects built up. A single impression of force is manifestly receivable by a sentient being devoid of mental forms: grant but sensibility, with no established power of thought, and a force producing some nervous change will still be presentable at the supposed seat of sensation. Though no single impression of force so received could itself produce consciousness (which implies relations between different states) yet a multiplication of such impressions, differing in kind and degree, would give the materials for the establishment of relations, that is, of thought. And if such relations differed in their forms as well as in their contents, the impressions of such forms would be organized simultaneously with the impressions they contained. Thus all other modes of consciousness are derivable from experiences of Force; but experiences of Force are not derivable from anything else. Indeed, it needs but to remember that consciousness consists of changes, to see that the ultimate of consciousness must be that of which change is the manifestation; and that thus force by which we ourselves produce changes, and which serves to symbolize the cause of changes in general, is the final disclosure of analysis.

"It is a truism to say that the nature of this undecomposable element of our knowledge is inscrutable. Force, as we know it, can be regarded only as a certain conditioned effect of the Unconditioned Cause—as the relative reality indicating to us an Absolute Reality by which it is immediately produced. And here, indeed, we see more clearly than before, how inevitable is that transfigured realism to which sceptical criticism finally brings us round. Getting rid of all complications, and contemplating pure force, we are irresistibly compelled by the relativity of our thought, to vaguely conceive of some unknown force as the correlative of the known force. Noumenon and phenomenon are here presented in their primordial relation as two sides of the same change, of which we are obliged to regard the last as no less real than the first."

Again: "But if what we call the translation-element in motion is not continuous, what is continuous? If, watching, like Galileo, a swinging chandelier, we observe, not its isochronism, but the recurring reversal of its swing, we are impressed with the fact that though at the end of each swing, the translation through space ceases, yet there is something which does not cease; for the translation recommences in the opposite direction. And on remembering that when a violent push was given to the chandelier it described a larger arc, and was a longer time before the resistance of the air destroyed its oscillations, we are shown that what continues to exist during these oscillations is some correlative of the muscular effort which put the chandelier in motion. The truth forced on our attention by these facts and inferences is that transference through space is not itself an *existence*: and that hence the cessation of motion, considered simply as translation, is not the cessation of an existence, but is the cessation of a certain *sign of an existence*—a sign occurring under certain conditions.

"Still there remains a difficulty. If that element in the chandelier's motion of which we can alone allege continuity, is the correlative of the muscular effort which moved the chandelier, what becomes of this element at either extreme of the oscillation? Arrest the chandelier in the middle of its swing, and it gives a blow to the hand—exhibits some principle of activity such as muscular effort can give. But touch it at either turning point, and it displays no such principle of activity. This has disappeared just as much as the translation through space has disappeared. How, then, can it be alleged that though the Motion through space is not continuous, the principle of activity implied by the Motion is continuous?

"Unquestionably the facts show that the principle of activity continues to exist under some form. When not perceptible it must be latent. How is it latent? A clue to the answer is gained on observing that though the chandelier when seized at the turning point of its swing, gives no impact in the direction of the late movement, it forthwith begins to pull in the opposite direction; and on observing, further, that the pull is great when the swing has been made extensive by a violent push. Hence the loss of visible activity at the highest point of the upward motion is accompanied by the production of an invisible activity which generates the subsequent motion downwards. To conceive this latent activity gained as an existence equal to the perceptible activity lost, is not easy; but we may help ourselves so to conceive it by considering cases of another class.

"When one who pushes against a door that has stuck fast, produces by great effort no motion, but eventually, by a little greater effort, bursts the door open, swinging it back against the wall and tumbling headlong into the room, he has evidence that a certain muscular strain which did not produce translation of matter through space, was yet equivalent to a certain amount of such translation. Again, when a railway porter gradually stops a detached carriage by pulling at the buffer, he shows that (supposing friction, etc., absent) the slowly-diminished motion of the carriage over a certain space is the equivalent of the constant backward strain put upon the carriage while it is travelling through that space. Carrying with us the conception thus reached, we will now consider a case which makes it more definite.

"When used as a plaything by boys, a ball fastened to the end of an india-rubber string yields a clear idea of the correlation between perceptible activity and latent activity. If, retaining one end of the string, the boy throws the ball from him horizontally, its motion is resisted by the increasing strain on the string; and the string stretched more and more as the ball recedes, presently brings it to rest. Where now exists the principle of activity which the moving ball displayed? It exists in the strained thread of india-rubber. Under what form of changed molecular state it exists we need not ask. It suffices that the string is the seat of a tension generated by the motion of the ball, and equivalent to it. When the ball has been arrested, the stretched string begins to generate in it an opposite motion, and continues to accelerate that motion until the ball comes back to the point at which the stretching of the string commenced—a point at which, but for loss by atmospheric resistance and molecular redistribution, its velocity would be equal to the original velocity. Here the truth that the principle of activity, alternating between visible and invisible modes, does not cease to exist when the translation through space ceases to exist, is readily comprehensible; and it becomes easy to understand the corollary that at each point in the path of the ball, the quantity of its perceptible activity, *plus* the quantity which is latent in the stretched string, yield a constant sum."—*Ibid*, 183.

Again: "Here, then, is the solution of the difficulty. The space-element of motion is not in itself a thing. Change of position is not an existence, but the manifestation of an existence. This existence may cease to display itself as translation; but it can do so only by displaying itself as a strain. And this principle of activity, now shown by translation, now by strain, and often by the two together, is alone that which in motion we call continuous."—*Ibid*, 187.

Again: "And now we reach the essential truth to be here especially noted. All proofs of the continuity of motion involve the postulate that the quantity of force is constant."—*Ibid.*, 188.

Again: "Nevertheless the forms of our experience oblige us to distinguish between two modes of force; the one not a worker of change, and the other a worker of change, actual or potential. The first of these—the space-occupying kind of force—has no specific name.

" For the second kind of force, distinguishable as that by which change is being caused or will be caused if counterbalancing forces are overcome, the specific name now accepted is 'energy.' That which in the last chapter was spoken of as perceptible activity, is called by physicists, 'actual energy'; and that which was called latent activity, is called 'potential energy.' * * * * To our perceptions this second kind of force differs from the first kind as being not intrinsic but extrinsic."—*Ibid*, 191.

Again: " while recognizing this fundamental distinction between that *intrinsic* force by which body manifests itself as occupying space, and that *extrinsic* force distinguished as energy, I here treat of them together as being alike persistent." *Ibid*, 192.

And again: " But now, what is the force of which we predicate persistence? It is not the force we are immediately conscious of in our muscular efforts; for this does not persist. As soon as an outstretched limb is relaxed, the sense of tension disappears. True, we assert that in the stone thrown or in the weight lifted is exhibited the effects of this muscular tension; and that the force which has ceased to be present in our consciousness exists elsewhere. But it does not exist elsewhere under any form cognizable by us. We saw that though, on raising an object from the ground, we are obliged to think of its downward pull as equal and opposite to our upward pull; and though it is impossible to represent these as equal without representing them as like in kind, yet since their likeness in kind would imply in the object a sensation of muscular tension, which cannot be ascribed to it, we are compelled to admit that force as it exists out of our consciousness is not force as we know it. Hence the force of which we assert persistence is that Absolute Force of which we are indefinitely conscious as the necessary correlate of the force we know. By the Persistence of Force, we really mean the persistence of some Cause which transcends our knowledge and conception. In asserting it we assert an Unconditioned reality without beginning or end."—*Ibid* p, 192.

§ 47. Now it is very doubtful if the reader can obtain a clear and definite notion of what it is that persists or how it persists from any one of these physicists, which is as much as to say that no one of them himself had clear and definite ideas on the subject, or that, if he had, he failed to find language to express them. And it is very certain that if the attempt is made to extract from them all a common principle on which they all harmonize it will be an utter failure; in fact, scarcely any one of them is consistent with himself, and it would seem that there must be some fallacy lurking about a supposed great basic principle which is so hard to grasp, comprehend, or interpret in language.

§ 48. And it may be noted here that the Persistence which alone can meet the requirements of material nature, and upon which Mr. Spencer relies for the basis of his philosophy is not merely a succession in events, a correspondence in phenomena, or an equivalence in action but a continuous existence, the same in essence through any and all transformations. Any thing less is not persistence. Whether it be force, or whether it be energy, or whether it be some other something, it, whatever it is, must retain its identity through all changes. Then, so far only as the facts, arguments and analogies presented by physicists go to establish a persistence of essence, existence, or being, are they legitimate premises for the conclusions of Conservation.

Yet it would seem that with the greater number of these thinkers it is an "equivalence of magnitude," a "quantitative equivalence" and not an identity of essence in which they conceive persistence as an element. There is the same space traversed, the same time, the same change of velocity, only reversed, the initial velocity of the ascent being the same as the final velocity of the descent; and, as they hold the heat developed by the impact, the equivalent in energy to the muscular or other energy which started the upward motion of any projectile. And in this corresponding equivalence they see Persistence, some in language which leaves it entirely uncertain as to whether they consider that beyond and beneath this quantitative equivalence there is a continuity of essence or not, while the language used by others seems to negative the latter notion altogether. Nevertheless, if there be not such sameness of some essential principle through all the phenomena there is no real persistence at all. For it is very clear that if all we know of it is simply an equivalence, of phenomena or action,—a series of successions of movements equal to each other by any unital measurement selected, it is equally possible for them to be the consequences of the same or of divers antecedents,—the effects of the same or of divers causes. It is equally possible and equally reasonable *a priori* to suppose that the causative antecedent of the fall of a stone is the quantitative equivalent of its rise, or of gravital pressure, or of some unknown antecedent. The notion of persistence without a persisting something as a *substratum*, is, therefore, illogical and self-destructive.

And the two ideas are of different orders of thought: the one quantitative wholly—a subject of mathematics purely, the other a question of identity of essence or being only, and in nowise subject to mathematics or mathematical formula.

§ 49. At the risk of being tedious, these several discussions of force and energy will be analyzed and the various propositions enunciated separately set out.

Wm. Lant Carpenter:

1. What was formerly known as the forces of nature are all only different manifestations of one principle.
2. That principle is the power of doing work.
3. Doing work is causing change.
4. The power of doing work resides in or acts through matter.
5. It is called energy.
6. Force is a particular kind of action upon a body;
7. By which its state of rest suffers change, or,
8. By which its state of uniform motion in a straight line suffers change.
9. Force can be known only by its effect upon matter.
10. Force is not a thing in the ordinary sense of the word.
11. Force is the rate at which change takes place in matter.
12. Force is like the bank-rate of interest or the birth-rate of children.
13. The essence of force is unknown.
14. The cause of force is unknown.
15. Energy and force do not mean the same thing.
16. Energy involves two distinct ideas combined.
17. Force involves only one idea.
18. Work is force exerted through space.
19. The idea of some kind of motion is connected with work.
20. A resting weight pushes the ground down with a certain force.
21. The ground pushes the weight up with the same force.
22. The resting weight can do no work.
23. That is it is incapable of producing motion.
24. The pressure of the weight is force.

25. The pressure of the weight is not energy.
26. Raising the weight is doing work.
27. Raising the weight involves the expenditure of energy.
28. When force acts there is a transference of energy from one portion of matter to another, or
29. There is a tendency to such tranference, and
30. Force in any direction is the rate of that transference.

§ 50. Prof. Thurston :

1. Matter and force are the two products of creation.
2. Energy is the fruit of the union of matter and force.
3. Matter, force and energy are indestructible by finite power.
4. Force is an attribute of matter.
5. In the beginning matter entered upon existence:
6. Endowed with its attributes, the forces of nature.
7. These forces acting upon all matter gave birth to actual energy, in
8. Fixed amount, and
9. Are capable of producing a fixed quantity of potential energy.
10. Energy remains as constant as matter.
11. The action of these forces upon this matter give rises to all phenomena.

§ 51. Wm. B. Taylor :

1. A stone thrown upwards loses tension, because
2. This is the law of distance-ratio for gravitative force, and
3. For no other reason.
4. It gains potential energy by the ascent, because

5. There has been a corresponding expenditure of kinetic energy in effecting the ascent.

6. There is absolute constancy between these two forms of energy.

7. This constancy is all that is meant by conservation of force.

8. There is no fixed relation between gravitative force and the production of motion.

9. The velocity of upward projection and the returning energy is always precisely the same.

10. The thing truly conserved is energy.
11. Force is not conserved at all.
12. Work is conserved.
13. Work is the offspring of force.
14. There is probably no such thing as force at all.

§ 52. Prof. Tait:

1. The actions and reactions of Newton are not simple forces,

2. But the products of forces into their velocities, or

3. The rates of doing work, or

4. The time-rate of increase of a very tangible and real something, for

5. The increase per second of a very tangible and real something, for

6. The measurement of which Watt introduced the horse power, which

7. Is the rate an agent works when it lifts 33.000 lbs. one foot high per minute,

8. Against gravity.

9. A hundred weight raised a few feet may do work in its descent.

10. A man cannot raise a ton, therefore
11. He cannot cause a ton to do work by falling.
12. Both the hundredweight and ton have pulled against him as hard as he pulled against them, but
13. There was work spent on the hundredweight, it moved, had velocity, and can do work.

14. No work was spent on the ton, for it did not move, therefore
15. It can do no work.
16. The work done on the hundredweight in raising it is stored in it ready for use at its fall.
17. Force is a mere name, but
18. The product of force into the displacement of the point of its application has objective existence.
19. Force is merely a convenient term to obviate cumbrous expression.
20. Force is not a thing,
21. Any more than a bank-rate or a birth-rate is a thing.
22. Energy is the power of doing work,
23. In whatever that power may consist.
24. The raised mass possesses energy,
25. By virtue of its elevation,
26. Precisely equal to the work spent in raising it.
27. This dormant or passive form is called potential energy.
28. Force is the agent in every change of motion.
29. Force is any cause.
30. Which alters a body's natural state of rest,
31. Or tends to alter a body's natural state of rest,
32. Or alters a body's uniform motion in a straight line,
33. Or tends to alter a body's uniform motion in a straight line.
34. Cause usually implies objective existence.
35. There is no proof of the objective existence of force.
36. In every case in which force is said to act, what is really observed is either a transference of what is called energy from one portion of matter to another,
37. Or a tendency to such transference.
38. Whenever such transference takes place, there is a relative motion of the portions of matter concerned.
39. And the so-called force in any direction is

merely the rate of transference of energy per unit of length for displacement in that direction,

40. Or the rate of transformation of energy per unit of length for displacement in that direction.

41. Force has not necessarily objective reality any more than has velocity or position.

42. In recent years it is recognized that something else in the physical universe has as high claim to objective reality as matter.

43. This something else is not so tangible as matter.

44. Heat and light are known by experiment to be varieties of energy,

45. And have as much claim to recognition on account of objective existence as matter.

46. The conviction of the objective reality of matter is based upon the fact that we cannot alter its quantity.

47. If there is anything else whose quantity we cannot alter we must admit it to have objective reality as truly as matter.

48. Heat, light, sound and electric currents must be regarded as being as real as matter because they satisfy the test which we adopt as conclusive of the reality of matter.

§ 53. *Stewart and Tait.*

1. Force is a pull, push, weight or pressure.

2. Force can be measured as equivalent to so many pounds weight.

3. Force is not properly work done by a force.

4. Force is not so many pounds raised so many feet.

5. Force does not mean force overcome through space.

6. Pressure and work done through space are of different kinds and cannot possibly be compared.

7. They differ as a linear foot differs from a square foot,

8. Or, as the measuring the height of a mountain in acres.
9. In all probability there is no such thing as force.
10. At the top of the cliff the ball has not energy due to actual motion, but
11. It has energy due to its elevated position, for
12. It has the power of doing work.
13. There are two forms of energy,
14. Which change into each other:
15. Kinetic due to actual motion,
16. And potential due to position,
17. Yet each change is a creation of one kind,
18. And a simultaneous annihilation of an equal amount of the other.
19. The total amount of energy always remains unaltered.
20. Energy is as much an objective reality as matter.
21. The only real things in the universe are matter and energy,
22. And matter is merely passive;
23. Therefore all changes are but tranfsormations of energy,
24. Including the actions and thoughts of living beings.

§ 54. Grant Allen:

1. Force is a power,
2. Which initiates aggregative motion,
3. Or accelerates aggregative motion,
4. While it resists or retards separative motion.
5. Energy is a power,
6. Which resists or retards aggregative motion,
7. While it initiates or accelerates separative motion.

§ 55. Balfour Stewart:

1. Rest is changed into motion by force,
2. In firing a gun by force of gunpowder, or

3. In the train by the force of the engine.
4. Motion is destroyed by force.
5. It takes equal amounts of force to produce motion and rest.
6. Force does not always produce motion.
7. A stone at the top of a precipice possesses force,
8. Of gravitation,
9. Which presses it down to the surface;
10. But there is no motion till the support is moved,
11. When this same force will cause it to fall downwards,
12. With a continually increased velocity,
13. Because it is free to obey the earth's attraction.
14. Energy is the power of doing work.
15. A stone shot upward has actual energy,
16. But when lodged on a house the actual has been changed into potential energy or energy of position,
17. And when it falls again it is changed back into actual energy,
18. And it reaches the ground with the same energy and velocity with which it started up.

§ 56. Judge Stallo:

1. Matter cannot be conceived as a mere passive spatial presence.
2. Force is nothing without mass.
3. Mass is nothing without force.
4. The physicist cannot grasp matter without force, nor
5. Force without matter.
6. Mass, inertia, or matter *per se* are indistinguishable from absolute nothingness.
7. Mass evinces its reality only by its action,
8. By its balanced or unbalanced force, or
9. By its tension or motion.
10. Pure force is nothing.
11. Force and inertia are conceptual integrants of matter, and

12. Neither is in any proper sense a fact.

13. In physics the term " force of nature " stands for a distinct and real entity.

14. As a mechanical function force is simply the rate of change of momentum, or

15. The differential of momentum at a given instant of time.

16. Momentum is the time-integral of force.

17. Force is not an individual thing or entity, but

18. Is purely an incident to the conception of the interdependence of moving masses.

19. The cause of motion or change of motion is the condition or group of conditions upon which the motion depends, and

20. This condition or group of conditions is a corresponding motion or change of motion in another body.

21. Force is a mere inference from the motion,

22. And its reality and measure lie wholly in the effect of which it is postulated as a cause, and

23. It has no other existence.

24. The only reality of force is the correspondence between physical phenomena.

25. That force has no reality is so plain that some thinkers have proposed to abolish the term altogether, as

26. The term cause has been abolished.

27. The very conception of force depends upon the relation of two terms, at least.

28. Force is but one aspect of the mutual action between two bodies, called by Newton

29. Action and reaction, more briefly expressed as

30. Stress ; and regarding one side of this stress.

31. We call it external force ; from the other side,

32. Reaction.

33. Force is an action between two bodies causing or tending to cause change in their relative rest or motion.

34. A constant central force belonging to an individual atom or molecule by itself is impossible.

35. Neither mass nor motion are substantially real, but,

36. Both are constituents of the concept of matter.

37. Whether these elements be *substance* and *accident*, or *matter* and *force* they are equally unreal, and,

38. No reality can be produced by their conjunction.

39. A body cannot survive the system of relations in which it has its being.

40. Its presence or position in space is not possible without reference to other bodies.

41. Nor is its change of position or presence possible without reference to other bodies.

42. Rest and motion are essentially relative.

43. In a double sense rest differs from motion as one motion differs from another.

44. Rest is but a special case of motion.

45. Rest is not the natural and original state of existence.

46. The question of the origin of motion in the universe admits of no answer, because

47. It is a question without intelligible meaning.

48. Force is purely a conceptional term, and

49. Is not a distinct tangible or intangible thing.

§ 57. Mr. Spencer:

1. Force is the ultimate of ultimates.

2. Space, time, matter and motion are either built up of or abstracted from experiences of force.

3. Matter and motion are differently conditioned manifestations of force.

4. Space and time are disclosed along with these different manifestations of force, as,

5. The conditions under which they are presented.

6. Deeper down than the mental relations of matter and motion, space and time are the primordial experiences of force.

7. A single impression of force is receivable,

8. But it cannot give consciousness.

9. A multiplication of such impressions gives the material for thought.

10. All other modes of consciousness are derivable from experiences of force, but

11. Experiences of force are not derivable from anything else.

12. Force by which we ourselves produce changes

13. Is the final disclosure of analysis.

14. The nature of force is inscrutable.

15. Force as we know it is a conditioned effect of the unconditional Cause.

16. Contemplating pure force we are compelled by the relativity of thought to vaguely conceive of some unknown force as the correlative of the known force.

17. The translation element in motion is not continuous, yet

18. There is something which continues;

19. Some correlation of the muscular effort by which the chandelier was pushed continues.

20. Transference through space is not an existence, and

21. Cessation of motions is not cessation of existence, but

22. Is the cessation of a sign of existence.

23. The principle of activity continues to exist under some form, and

24. When not perceptible must be latent.

25. The loss of visible activity is accompanied by the production of invisible activity.

26. A muscular strain which does not produce translation may be equivalent to a certain amount of translation.

27. The principle of activity alternating between visible and invisible modes does not cease to exist when translation through space ceases to exist.

28. The quantity of perceptible activity plus the quantity which is latent yields a constant sum.

29. The space element of motion is not itself a thing.

30. A change of position is not an existence,

31. But the manifestation of an existence.

32. This existence may cease to display itself as translation, but

33. It can do so only by displaying itself as a strain,

34. And this principle of activity is alone that which is called continuous in motion.

35. All proofs of the continuity of motion involve the postulate that the quantity of force is constant.

36. We are obliged to distinguish between two forms of force,

37. One not a worker of change,

38. The other a worker of change, actual or potential.

39. The first kind has no specific name.

40. The second is called energy.

41. That spoken of as perceptible activity is called actual energy,

42. And the latent activity, potential energy.

43. The second kind differs from the first kind as being not intrinsic but extrinsic,

44. Here treated of together as being alike persistent.

45. It is not the force we are conscious of in our muscular efforts which is persistent,

46. For this does not persist.

47. We say the force which has ceased to be present in our consciousness exists elsewhere,

48. But it does not exist elsewhere under any form cognizable to us.

49. Force as it exists out of our consciousness is not force as we know it.

50. The force of which we assert persistence is that Absolute Force of which we are indefinitely conscious as the necessary correlate of the force we know.

51. By the persistence of force, we mean the persistence of some cause which transcends our knowledge and conception.

52. In asserting it we assert an Unconditioned Reality without beginning or end.

§ 58. It would naturally be expected that a doctrine accepted as an axiomatic truth by the whole intelligent world, lauded by the most distinguished thinkers of the age as the grandest of all scientific achievements, utilized as the foundation rock of all-embracing systems of philosophy, and yielded without a word of dissent as a vantage ground for the assaults of agnosticism upon revealed religion, would be found to be a conception so clearly limned in thought and so definitely expressed in language that the great scientists at least, should have been able to obtain sufficient grasp of the idea to have given an intelligible, consistent, and accurate definition and elucidation of it. If they have not done so, we may well believe that it is because the doctrine is in its nature so obscure that the greatest intellects in the world are unable to get a clear, firm, mental hold of it. *That* they have not done so, the discordant, vague, indefinite and self-contradictory notions entertained on the subject as appearing in the foregoing quotations and analyses abundantly establishes. And we may, right here, most logically conclude, that if the doctrine be true at all, the scientists do not know it and have only the most shadowy reasons for believing it.

Inconsistencies.

§ 59. But that we may, if possible, obtain something approaching to clear ideas on a very obscure subject, the true scientific theory of conservation, the various dissertations on the matter just quoted will be examined. Wm. Lant Carpenter differs very broadly from Mr. Spencer in this: that while Mr. Spencer makes energy a species of the genus force, Mr. Carpenter, on the contrary, makes force a species of the genus energy. But Mr. Carpenter differs from himself more than he does from Mr. Spencer, for he gives six variant definitions to force: "various forces were all different manifestations of a power of doing work;" "Force may be defined as that action upon a body, under which the state of rest of that body, or its state of uniform motion in a straight line, suffers change;" "Force is simply the expression of the rate or speed at which any change takes place in matter;" "Work is force exerted through space;" "The pressure that the inert weight produces is force;" "Force in any direction is simply the rate of the transference of energy from one portion of matter to another," that is to say, force is "a manifestation of energy," (power of doing work), it is "action upon a body," it is "an expression for rate or speed of change," it is "work," it is "pressure," it is the "rate of transference of energy from one portion of matter to another." And we may well conclude that if Mr. Carpenter had any clear notion of force in his own mind he has failed to communicate it to his readers. "Energy," he tells us, "is the power of doing work," and "the operation of raising the weight is doing work and involves the expenditure of energy." That is "doing work" "involves the expenditure" of "the power of doing work," all of which appears exceedingly misty. On page 3 Mr. Carpenter tells us that energy "is never created afresh nor destroyed entirely" which "is the idea intended in the phrase conservation of energy." So it is energy, or that "power of doing work" which "expends itself in doing work" which is the conserved, according to Mr. Carpenter.

§ 60. Prof. Tait is not consistent with himself, for he first tells us that Newton's actions and reactions are but products of forces into their velocities, and then that "force is a mere name." If a mere name, it can have no velocity and the equivalent proposition would be "Newton's actions and reactions are but products of mere names into zero." But he gravely tells us "that force is a mere name, but the product of a force into the displacement of the point of its application has an objective existence." The "displacement" spoken of must be some *distance* in space. The proposition then is that the product of "a mere name" into distance has an objective existence. Were not this the language of a great physicist in trying to elucidate a great system of philosophy it would seem too absurd to merit a moment's attention. But it must be examined.

§ 61. A product is possible mathematically or logically only as between quantitative entities. A *name* can be used neither as a multiplier nor multiplicand. A product is the taking one quantity as many times as there are certain measuring units in another quantity or number. A name is not a quantity to be repeated nor a number to represent the units of repetition, nor a thing that can have, contain, or be composed of units.

Again he tells us force is not a thing, yet that it has velocity. And really there must be something wrong in the interpretation Prof. Tait puts upon Newton's language. Newton could not have meant forces either in the popular sense or in Prof. Tait's sense because the proposition would not have been and is not true unless "forces" be taken in a yet different sense, to wit, in the sense of masses :—in that sense it is true, the masses on one side, taken as many times as some particular unit is contained in their velocities, will always equal the masses on the other side taken as many times as the same unit is contained in the velocities on that side.

Test of Reality,

§ 62. Prof. Tait's test of objective reality is not satisfactory. It is scarcely more than a century ago that it was shown by experiment that the quantity of matter cannot be altered. According to his reasoning, before that time the world could not have known the "objective reality of matter." Does he suppose physicists prior to that time had a grasp any less firm on the reality and objectivity of matter than he now has? Does he suppose that the ignorant laborer who never heard of the experiments referred to has not a certain conviction that the tools he handles, and the stones he breaks, are both real existences, and objective to himself?

§ 63. And look to the experiments. Prof. Tait lights a candle or builds a bonfire. Two of his objective realities, heat and light, flash into form, but what becomes of them? They go out in right lines, some to be impeded and cut off, others to traverse illimitable space. Can Prof. Tait say they are not extinguished, annihilated? Does his experiments or his mathematics either serve him there? And what basis has he to reason from but hypothesis and guess-work? Again, can he by experiment increase or diminish the quantity of his own *mind?* If not, by the test it should not only be real but objective to himself.

§ 64. But he mistakes the whole question. Neither reality nor objectivity are matters of experiment, but necessary forms of thought under certain conditions. When the sense of vision becomes active by the impinging of a ray of light upon the retina, the mind sees the color of green, perhaps, reflected from some object, a tree, for instance,—it sees and thinks the tree green, and what does that amount to? Why, that the tree has reflected particular rays of light, which affect the sense of sight in a particular way, and the mind calls it green; it says the tree acts green, conducts itself in a green way, that is, that it causes a green affection in the vision. Now it may be true that there is no resemblance between the subjective sensation and the objective tree, yet it is equally true that the one causes, or is the occasion of, the other; and in that sense it is both real and objective, and the notion of philosophers that either should be doubted because there is no unit of comparison between sensations and external objects is fallacious in the highest degree.

§ 65. But to a different form of illustration. The candle is lighted, the heat is felt, the light is seen, the candle wastes away, change is going on. These are sensational facts, experiments; but formed in the mind coincident with their reception is the notion that *something* does it, that *something* produces the change, that there is a *cause* at work there, and that notion is one the mind cannot divest itself of so long as the change goes on. And it is a notion of reality in the sense of actual existence or entity, and of an objectivity to self. It matters not what this *something* may be called, whether cause, force or energy, under whatever name, its essence and office are the same, and the mental recognition of it the same.

I prefer to call it force—the old name. But physicists, with Prof. Tait at their head, seeing that forces do disappear, and thereby discredit conservation, have been curious to find something of which they can predicate continuity through all changes, and, therefore, have hit upon "energy," clad her in several mythical characters, as, for instance, the potential form, and substituted her for force. "Potential energy" will be extensively discussed hereafter; but while we are getting to it, it will not be out of the way, perhaps, to ask Prof. Tait and his school of physicists for one single experiment showing that the projectile force which carried the ball or stone to the top of the house or cliff was changed in the ascent into a *potential* form, or will, when dislodgment takes place, be re-transformed into actual energy. Prof. Tait having laid down the proposition that nothing can pass in science except experiment and mathematical reasoning thereon, he should not hesitate to give us first the experiment, and then the reasoning, particularly as he has found that energy, *including this potential form*, is entitled to the same recognition as an *objective reality* as matter itself.

§ 66. Prof. Thurston says that force and matter are products of creation; that force is an attribute of matter, and that it acts upon matter in producing energy and all phenomena. Now if force is an attribute of matter, it is not seen how it can have been a product of creation in the same sense that matter was, nor how, in any sense, it can be said to act upon matter—an attribute or quality upon its substratum or substance. It will be noticed that here is one additional definition to those given by Mr. Carpenter.

§ 67. Mr. Taylor tells us: "The thing truly conserved is energy;" then he says, "Work is conserved." Prof. Thurston says: "Matter, force and energy are indestructible by finite power;" but Mr. Taylor says: "Force is not conserved at all. The former says force was one of the products of creation, and Mr. Carpenter gives four or five definitions of force, but Mr. Taylor says there is probably no such thing at all.

§ 68. Prof. Tait defines energy as Mr. Carpenter does. He also speaks of the "power of doing work" as an agent, and he finds an essential distinction between the unsuccessful and successful efforts at raising a stone, thus differing from Mr. Spencer, who sees in the violent bursting open of a door after continued pressure, only a continuation of the same exhibition of force. It will be shown, hereafter, that in this Prof. Tait is wrong and Mr. Spencer right. Upon the whole, Prof. Tait's position is only a little less self-contradictory and considerably more dissonant to reason than Mr. Carpenter's.

§ 69. Stewart and Tait contradict themselves in saying, first, that force is a pull, push, weight, or pressure, and then that "in all probability there is no such thing as force." Both these propositions contradict Prof. Tait when he says force is a "mere name." If it is a pull or a push it is much more than a name; if there is no such thing, it is less than a name. Of course there is no concession to these authors when they affirm that the exertion in a push is no more comparable to that in actual translation than is a linear to a square foot.

These distinguished physicists define energy as others have done—the power of doing work, and not only assign persistence to it, but make it one of the only two existing realities of the universe. This will give occasion for a curious criticism at the proper place.

§ 70. Grant Allen differs from all the others in that he makes force and energy two opposing principles.

§ 71. Balfour Stewart comes more nearly agreeing with Mr. Spencer than any of them ; indeed, it is not seen that there is any marked disagreement between them, but Mr. Stewart curiously contradicts himself in saying, first: "But this same force which causes the pressure of the stone against its support will cause it to fall downwards over the side of the cliff, with a continually increasing velocity when once the support is removed and it is free to obey the attraction of the earth," and then, "the energy of actual motion with which it started has been changed into another form of energy, which we denominate energy of position or potential energy, and that by allowing the stone again to fall we may change this energy of position once more into actual energy." It would seem that Mr. Stewart is opposed to Tait on the question of the reality or unreality of force.

§ 72. Mr. Stewart has made the most of the hypothesis of "Energy of Position," a doctrine which will come up repeatedly for notice in this discussion. It only needs to be observed here regarding it, that energy, being defined as the "power of doing work," is, therefore, as we have seen, an attribute or property of *something*, and since "doing work" is defined as producing motion, it follows that wherever motion exists, there work is being done, and where work is being done, the "power of doing work" must be present. And therefore, since the "power of doing work" is an *attribute of something*, it follows either that an attribute must act separate and disparate from its substance, which is absurd, or else *that something* of which the "power of doing work" is an attribute, must be present in every motion of matter.

§ 73. A further necessary corollary is that if the power of doing work can become latent, as in the supposed energy of position, the *something* which constitutes its substratum must even there be existent and present, for the contrary notion would involve a double absurdity, first, that an attribute can exist at all abstracted from its substance, and next, that so abstracted it can have a real existence in an inactive, insensible mode. And then follows the further absurdity that upon occasion this latent, abstracted attribute can spring into visible and energetic activity in its still disparate state.

Spencer's Notion of Force.

§ 74. It will be observed that Mr. Spencer surrounds this discussion of force and persistence with an atmosphere of abstruse metaphysics, which is detrimental to clear conceptions, and foreign to the requirements of scientific physics. But, all this aside, it will be noticed in the first instance, that he distinguishes "force as we know it" from "absolute force of which we are indefinitely conscious," and "which transcends our knowledge and conception." In the next place, "force as we know it," he distinguishes into "space-occupying force without a name," "not a worker of change," and "energy," "a worker of change." The former he calls *intrinsic* and the latter *extrinsic*. The "extrinsic", "worker of change", is sub-divided as "actual energy and potential energy," otherwise as "perceptible force," and "imperceptible force." The propriety of these distinctions will not be criticised at this time further than to remark that it is only with "force as we know it" that physical science can have to do at all. Any other character of force, if there be any other, belongs to the realms of pure metaphysics and faith.

But from the above quotations the remarkable fact appears that Mr. Spencer is not consistent with himself. In the first instance he gives us to understand that what persists "is some correlative of the muscular effort which put the chandelier in motion;" that "the principle of activity continues to exist under some form. When not perceptible it must be latent;" that "a certain muscular strain which did not produce translation of matter through space was yet equivalent to a certain amount of such translation;" that "the slowly-diminished motion of the carriage over a certain space is the equivalent of the constant backward strain put upon the carriage while it is "travelling through that space;" that "the principle of activity exists in the strained thread of india-rubber;" that "the principle of activity, alternating between visible and invisible modes, does not cease to exist when the translation through space ceases to exist;" that "this existence may cease to display itself as translation, but it can do so only by displaying itself as a strain;" that "this principle of activity, now shown by translation, now by strain, and often by the two together, is alone that which in motion we call continuous." He then tells us that both "space-occupying force" and "change-working force" are persistent. "While recognizing this fundamental distinction that *intrinsic* force by which body manifests itself as occupying space, and that *extrinsic* force distinguished as energy, I here treat them together as being alike persistent." And then he asserts: "Hence the force of which we assert persistence is that absolute force of which we are indefinitely conscious as the necessary correlate of the force we know. By the persistence of force we really mean the persistence of some cause which transcends our knowledge and conception. In asserting it we assert an unconditional reality without beginning or end."

To repeat: Mr. Spencer first declares that only "energy," "*extrinsic* force," "change-working force," persists; then, that not only the latter but also "space-occupying," "*intrinsic*," "not change-working" force also persists; and, finally, that only "Absolute Force," "which transcends our knowledge and conception," which means, if the writer is able to get hold of Mr. Spencer's ideas, the "great Unknowable," and all that his system gives us of Deity, persists. And on the latter proposition it may be remarked that while, of course, no one who admits the present existence of either Mr. Spencer's Unknowable or of Deity in the ordinary conception can doubt his omnipersistence or eternality, it cannot be perceived how this attribute of His being presents a basis for the formulation of a philosophy explanatory of all existence.

Force a Reality.

§ 75. But let us try to get at Mr. Spencer's meaning in the use of the word force, if there be any one elemental idea running through his various applications of the term. And there does seem to be one basic notion presented in all of them, that of a *thing*, *reality* or *existence*. It is the "ultimate of ultimates." "Matter and motion, as we know them, are differently conditioned manifestations of force." "Deeper down than these, however, are the primordial experiences of force." "Thus all other modes of consciousness are derivable from experiences of force; but experiences of force are derivable from nothing else." "Force is the final disclosure of analysis;" "force, as we know it, can be regarded only as a certain conditioned effect of the unconditioned cause—as the relative reality indicating to us an absolute reality by which it is immediately produced;" "the translation through space ceases, yet there is *something* which does not cease." "What continues to exist during these oscillations is some correlative of the muscular effort which put the chandelier in motion." "The cessation of motion, considered simply as translation, is not the cessation of an existence, but is the cessation of a certain sign of an existence;" "the principle of activity continues to exist." "To conceive this latent activity gained as an existence equal to the perceptible activity lost, is not easy;" "a certain muscular strain which did not produce translation of matter through space, was yet equivalent to a certain amount of such translation;" "it exists in the strained thread of india-rubber;" "the string is the seat of a tension generated by the ball and equivalent to it;" "the principle of activity, alternating between visible and invisible modes, does not cease to exist;" "the principal of activity continues to exist;" "the space-element in motion is not itself a thing; change of position is not an existence, but the manifestation of an existence; this existence may cease to display itself as translation, but it can do so only by displaying itself only as a strain." "All proofs of the continuity of motion involve the postulate that the quantity of force is constant;" "force as it exists out of our consciousness is not force as we know it."

So that in all aspects of the question Mr. Spencer seems to use the term force as meaning a real something, an existing principle, a veritable entity, subject to quantitative measurement, and on this notion his philosophy is founded.

But the wonder remains that Mr. Spencer was content to take for the foundation principle of his great system a doctrine based upon a principle about which his views were so uncertain as to admit of the diverse definitions of the "change-working force" with which we are so well acquainted, and next, that "absolute force" "which transcends our knowledge and conception." It would seem that to give a system of philosophy proper standing and full credit, one should be able to find for it some bed-rock principle about which he could entertain and express more definite and consistent notions than Mr. Spencer has done of the "force which persists."

And yet when we reflect that Mr. Spencer has taken this "first principle" as furnished by the great physical thinkers of the fifty years just past, the wonder will be that he has been able to make so much out of a mass of notions so shadowy and heterogeniously discordant as we have found in the writings of modern physicists on the subject.

And the greater wonder will be yet, that the intellectual and learned world has been content to receive from the physicists without question, and welcome with *eclat* into the very inner shrines of thought, a priestess with credentials so obscure, indefinite and contradictory, though bearing the proud name of Conservation, to break with iconoclastic hands the oldest beliefs, the oldest faiths, and the oldest hopes of the human mind and heart, and the most sacred as well.

CHAPTER VI.

Six Systems of Philosophy.

SIX FUNDAMENTAL IDEAS—DISTINGUISHED BY STALLO—FIRST THEORY—SECOND THEORY—THIRD THEORY—FOURTH THEORY—FIFTH THEORY—SIXTH THEORY.

§ 76. It seems proper in the next place to notice the several prominent theories of the underlying principles of physical nature upon which the opinions of physicists have been divided.

Force and Matter.

Of these there are at least six philosophical systems regarding the physical constitution of nature which must be severally thoroughly comprehended before the various aspects of the doctrine of conservation can be grasped. These six systems all concern the character or cause of motion in matter. That acute thinker, Judge Stallo, has lucidly set forth the first of these theories:

§ 77. "Forty years ago," says he, "the creed of an ordinary physicist was something like this: Primordially there existed, through an act of creation or from all eternity, myriads of hard and unchangeable material particles. There also existed certain forces equally unchangeable, such as the forces of attraction and cohesion, heat, electric, magnetic, chemical forces, and so on. To the constant or variable, partial or concurrent action of these forces upon the material particles are due all the phenomena of physical reality. In this action the material particles are the passive and the forces the active element; but these elements, of course, pre-exist to the action. Matter itself is passive, dead; all motion or life is caused by force; and the only possible solution of the problems of physiology, no less than those of physics and chemistry, consists in the enumeration of the forces acting upon the material particles and in the exact quantitative determination of the effects produced by their action."—*Concepts of Modern Physics, p.* 152.

It may be added that this theory considers force as an entity or positive, real existence, but not necessarily, nor *possibly*, perhaps, a *substantial* existence in the sense of possessing any of the attributes known as material.

Two Species of Force, Kinetic and Potential.

§ 78. Letting the same writer state the second theory: "It," modern science, "asserts that all or nearly all physical changes in the universe are mutual conversions of kinetic and potential energies—that energy is incessantly stored as virtual power and restored as actual motion. When the bob of an ordinary pendulum descends from its highest to its lowest point, its potential energy diminishes in proportion to the increase of its actual motion; when it rises again, its energy of motion disappears at the same rate up to its arrival at its highest point opposite the first, where it is for an instant motionless, all its energy being due to its position. And this conversion and reconversion of the two forms of energy are typical alike of the supposed oscillations of the ultimate atoms or molecules and of the orbital swing of the large bodies composing a planetary system. A planet moving in an eccentric orbit gains energy of motion as it approaches the sun and loses it again in the same proportion as it recedes from it. The same mutual transformation is exhibited in another wide domain of physical phenomena: action due to chemical affinity. A lump of coal lies buried in the earth for a million years; during all this time there is no appreciable change in its position as referred to surrounding objects, or in the relative position of its parts—it is without external or internal motion (except that which it shares with the planet of which it is a part); now we bring it to the surface, into the atmosphere containing oxygen, and into contact with a flame; its latent power at once becomes sensible—it burns, giving rise to vigorous action, which manifests itself as light and heat. The tendency of modern science is to trace all physical change to a few primary forms of potential energy, chief among which are gravity and chemical affinity. In the opinion of modern physicists, the only plausible theory thus far advanced of the origin of stellar and planetary systems is that known as the nebular hypothesis; and whether we adopt its familiar Kant-Laplacean form, or one of its more recent modifications, in either case all the molar, if not the molecular, forces of the universe are ultimately derived from the attraction due to the mere position of the original particles supposed to be uniformly diffused in space. And all changes in the comparatively minute organic or inorganic forms are referred, proximately at least, in physiology as well as in physics, to the affinities of the chemical elements.

"In truth, modern science teaches that diversity and change in the phenomena of nature are possible only on condition that energy of motion is capable of being stored as energy of position. The relatively permanent concretion of material forms, chemical action and reaction, crystallization, the evolution of vegetable and animal organisms—all depend upon the 'locking up' of kinetic action in the form of latent energy."—*Ibid.* 67.

"The conformity of the principle of the conservation of energy to the facts of experience is sufficiently apparent whenever we deal with visible or otherwise perceptible changes in the position or configuration of a body or system of bodies, such as the action of gravity, the strain of an elastic body, etc. In these cases we readily see that energy is alternately stored as energy of position and restored as energy of motion. But there is a class of cases in which there is loss of energy of motion without manifest change of position. When two equal inelastic bodies, moving with equal velocities in opposite directions collide centrally, there is, apparently at least, a total destruction of motion, and there is no gain of position, for the bodies remain at rest at the point of collision. A similar loss of actual energy is observed whenever work is done against friction. What becomes of the energy of motion which seems to disappear in cases of this kind? To this question Newton clearly had no definite answer. He expressly asserted that "motion may be got or lost," and that, "the *vis inertiæ* being a passive principle ... some other principle was necessary for putting bodies into motion, and now they are in motion, some other principle is necessar for conserving the motion.... By reason of the tenacity of fluids, and attrition of their parts, and the weakness of elasticity in solids, motion is much more apt to be lost than got, and is always upon the decay." But it is an error to maintain with Stewart and Tait, that the answer was unknown in Newton's time. The answer of modern science, which is that the apparent loss of molar motion results from its real conversion into molecular motion, was anticipated by Leibnitz, as shown in the following remarkable passage found in his fifth letter to Clarke: "I had maintained that the active forces are conserved in the world. It is objected that two soft or inelastic bodies, when they collide lose part of their force. I answer, they do not. It is true that the whole loses it in reference to their total movement; but it is received by the particles, they being agitated inwardly by the force of the collision. Thus the loss ensues only in appearance. The forces are not destroyed, but dissipated among the minute parts. This is not losing them, but it is doing what those do who turn money into small change."—*Ibid*, 80.

Force the only Existence.

§ 79. Judge Stallo may state the third theory thus: "One of the most noted controversies of the time is that between the champions of the *mechanical* or *corpuscular* theory of matter, who assert that it is a real thing independent of force, and the defenders of the *dynamical* theory, who maintain that material particles are mere centres or spheres of force. The corpuscular theory is held by the majority of physicists in common with ordinary men, while the dynamical view—originally the outgrowth of metaphysical speculation—has been broached, on grounds that are alleged to be non-metaphysical, by Boscovich, Ampere, Faraday, and others. Faraday's opinion is concisely stated by Tyndall: 'What do we know of the atom apart from its force? You imagine a nucleus which may be called *a*, and surround it with forces which may be called *m*; to my mind the *a*, or nucleus vanishes, and the substance consists of the powers *m*. And, indeed, what notion can we form of the nucleus independent of its powers? What thought remains on which to hang the imagination of an *a*, independent of the acknowledged forces?' And quoting from Aristotle: 'It is a mere delusion of the fantasy that something, we know not what, remains after we have denuded an object of all the predicates which belong to it.'"—*Ibid*, 159.

Force an Element of Matter.

§ 80. The fourth theory may be given by continuing the quotation from Judge Stallo: "In the main this creed is evidently a reproduction of the old synthetic view of metaphysics. And it is gradually giving way to a new doctrine which is similarly a reproduction of the metaphysical sequel which I have termed the analytical or evolutionary view. The recent theories of the correlation and mutual convertibility of forces, as part of the principle of conservation of energy, have shaken, if not destroyed, the notion of a multiplicity of independent original forces; and, moreover, physiologists like De Bois-Reymond recognize force as the invariable concomitant, if not as the essential attribute or primary quality of matter, asserting that to every constant primordial mass belongs a constant primordial quantity of force, and that all the transformations of matter are produced by a differentiation of this primordial force. From this the suggestion is natural that all the varieties of physical existence were potentially contained in and have been gradually evolved from matter in general, or matter *per se*." Continuing, he quotes from Prof. Tyndall's celebrated "Belfast lecture:" "Abandoning all disguise, the confession that I feel bound to make before you is that I prolong the vision backward across the boundary of the experimental evidence, and discern, in that matter which we, in our ignorance, and notwithstanding our professed reverence for its Creator, have hitherto covered with opprobrium, the promise and potency of every form and quality of life." From Lord Bacon he quotes: "And matter, whatever it is, must be held to be so adorned, furnished and formed, that all virtue, essence, action, and motion may be the natural consequence and emanation thereof." And from Schelling: "Matter is the general seed-corn of the universe wherein everything is involved that is brought forth in subsequent evolution." And again: "Bodies are said to be *endowed* with a definite quantity of force; it is assumed that to every particular body or atom belongs, or that in such body or atom is inherent, an invariable measure of energy." *Ibid.* 169.

And from Prof. Thomas Graham: "With the atom at rest the uniformity of matter would be perfect. But the atom possesses always more or less motion, due, it must be assumed, to a primordial impulse. This motion gives rise to volume. The more rapid the movement the greater the space occupied by the atom, somewhat as the orbit of a planet widens with the degree of projectile velocity. Matter is thus made to differ only in being lighter or denser matter. The specific motion of an atom, being inalienable, light matter is no longer convertible into heavy matter. In short, matter of different density forms different substances, different inconvertible elements as they have been considered."—*Ibid.* 32.

Force a Relation.

§ 81. The fifth theory, which may be designated as *Judge Stallo's own*, has already been given in his own language. (§ 45.)

Nothing Mass and Motion.

§ 82. Again letting the same philosopher set forth the sixth theory, a number of quotations are made: "In order to account for the differences and changes in the material world, this inert element *matter* obviously requires to be supplemented by another element; and this element, according to the adherents of the atamo-mechanical theory, is *motion;* whereas in the view of its opponents it is *force.* This force is assumed to be an independent, substantial entity, which is not a property of matter, nor essentially related to matter, otherwise than by its power to act upon it.''—*Ibid. Introduction, p.* 31. "Modern physical science aims at a mechanical interpretation of all the phenomena of the universe. It seeks to explain these phenomena by reducing them to the elements of mass and motion and exhibiting their diversities and changes as mere differences and variations in the distribution and aggregation of ultimate and invariable bodies or particles in space."—*Ibid*, 17. "In the light of this theory the ultimates of scientific analysis are *mass* and *motion*, which are assumed to be essentially disparate. Mass, it is said, exists independently of motion and is indifferent to it. It is the same whether it be in motion or at rest. Motion may be transferred from one mass to another without destroying the identity of either."—*Ibid*, 25. "Accordingly the mechanical theory of the universe postulates the conservation of both mass and motion. Mass may be transformed by an aggregation or segregation of parts; but amid all these transformations it persistently remains the same. Similarly, motion may be distributed among a greater or less number of units of mass; it may be transferred from one unit of mass to any number of units, its velocity being reduced in proportion to the number of units to which the transference takes place; nevertheless, the sum of the motions of the several units is always equal to the motion of the single unit. It may be changed in direction and form; rectilinear motion may become curvilinear, translatory motion may be broken up into vibratory motion, molar motion may be converted into molecular agitation; yet, during all these changes it is never increased, diminished or lost."—*Ibid*, 26.

"It is thus seen that the theory according to which the cause of all phenomenal change and variety in nature is motion, and all apparent quantitative diversity is in reality quantitative difference, involves three propositions, which may be stated as follows:

"I. *The primary elements of all natural phenomena —the ultimate scientific analysis—are mass and motion.*

"II. *Mass and motion are disparate. Mass is indifferent to motion, which may be imparted to it, and of which it may be divested, by a transference of motion from one mass to another. Mass remains the same, whether at rest or in motion.*

"III. *Both mass and motion are constant.—Ibid*, 27.

"1. *The elementary units of mass, being simple, are in all respects equal.* This is manifestly nothing more than an assertion of the homogeneity of mass in conformity with the hypothesis of its molecular or atomic constitution.

"2. *The elementary units of mass are absolutely hard and inelastic;*—a necessary consequence of their simplicity, which precludes all motions of parts, and, therefore, all change of figure.

"3. *The elementary units of mass are absolutely inert and therefore purely passive;* hence there can be no mutual action between them, other than mutual displacement, caused by impulses from without.

"4. *All potential energy, so called, is in reality kinetic.* Mass and motion being fundamentally disparate and inconvertible, and mass being absolutely inert, whatever be its position, motion cannot originate in, or be caused by, anything but motion. Energy due to mere position, therefore, is impossible."—*Ibid*, 28.

"According to the mechanical theory, motion, like mass, is indestructible and unchangeable; it cannot vanish and reappear. Any change in its rate results from its distribution among a greater or less number of units of mass. And, motion and mass being mutually inconvertible, nothing but motion can be the cause of motion. There is, therefore, no potential energy; all energy is really kinetic."—*Ibid.* 66.

§ 83. To recapitulate, we have the following theories of motion:

1. All motion is produced by an independent primordial entity called force acting upon matter.

2. The same with the modification added that this entity may oscillate between reality and nonentity, passing from something (kinetic force), to nothing (potential force), and back again, as occasion may arise.

3. Not only is force an independent primordial principle, but it is the whole constituent or only element of matter. Instead of being force and matter there is only force in existence.

4. Force is an integral element of matter, or rather, perhaps, an inherent and inalienable principle or attribute of matter.

5. Force is nothing but a relation between atoms or bodies, only a *status* or attitude of portions of matter towards each other, and rest and motion are likewise relations.

6. There is no force, nothing existing but matter and motion. What is called force is only a *causeless* transference of motion from one portion of matter to another.

§ 84. Perhaps no single school of physicists, and no single physicist will be found to hold to views which will exactly fit within either one of these definitions, but it is believed that a critical examination of the philosophy of any prominent modern physicist will show that the body of his system, so to speak, coincides, more or less closely, with some one of the systems above defined, while the extremities or appendages may, more or less, overlap one or more of the others. It is not intended at this time to exhaustively examine any of these views, but a cursory survey of some of them will be a profitable introductory to the consideration of the doctrine of conservation, which each is supposed, by its own adherents, to support.

§ 85. In doing so it will be convenient to take them in reversed order, the last first, and so on. And in discussing this proposition it may be noticed in the first instance, that as the second in the series predicates a *potential* form of force or energy in order to meet the requirements of conservation, so does this proposition presume a potential form of motion to meet the exigencies of the same doctrine, for if when bodies come to rest, and are apparently still and inert, there is not a motionless form of motion; that is the end of the proposition. But as this notion of potential energy, force or motion will occur again for exhaustive consideration, it will not receive further consideration at this time.

Materialism.

§ 86. Attention may next be drawn to the fact, that this is an absolute form of materialism, since it sees and knows nothing in nature but matter and its movements, not even admitting a cause for anything that occurs, but only a necessary succession of events consequent upon conservation and transference of motion according to the original constitution of matter. As a corollary it is, of course, an absolute necessarianism or fatalism.

§ 87. A logical inference from the hypothesis is that, as all change is without cause, save antecedent change, so must all change be without results, except only subsequent and consequent change, and as there is nothing but matter and its motions, mind can be nothing but a series of motions, and thought but a term in the series, but a link in the concatenation of material changes.

§ 88. And while this theory is essentially and absolutely materialistic in its results, it is, or considers itself, wholly sensational in its genesis. It is founded, or at least claims to be founded, solely on experience that is, on the evidence of the senses. It may be called emphatically the experiential theory. It rejects the notion of *cause*, because we have, it is claimed, no experiential knowledge of a cause. It rejects the notion of *force*, because we can neither see, hear, feel, taste, nor smell, force. Matter and motion are testified to by by all the senses, therefore, we know they exist, and we are entitled to use them as real intelligible predicates of the understanding. But that of which we can have no sensible experience we have no logical right to use in thought as real existences, for as we cannot know their reality they should be to us as non-existent.

§ 89. But let us apply this mode of reasoning to some other concepts, and see where it will land us. We can neither see, hear, touch, taste, nor smell, time or space. We can have no sensible knowledge of them. All we know of the concept of time is, that it is an attendant or concomitant of events as space is of matter and motion. The one is a mould or form, so to speak, in which the concept of events, and the other in which the concept of matter, always appear. In thought, space is as different from the sensational idea of matter or body as it is possible for any two notions to be, and yet the notion of matter is utterly unthinkable without its wrappings of spatial thought. So of the notion of mind, soul, the ego. No sensation brings us in contact with it. We think, we desire, we will, we act, and by and in the doing of these things, we know our minds exist; or, rather, I thus come to know the reality of my own mind, and you thus come to know the reality of your own mind. But I have precisely the same evidence, and no other, of the existence of your mind, and you have precisely the same, and no other, of the existence of my mind that we both have of a cause for the blowing of the winds, the fall of the rain, or the flowing of the waters. I see your body move, I hear your voice, I touch your hand, but I cannot see, hear, nor feel, your mind; therefore, I can have no sensual knowledge of it. I must either assume that you have no mind, nothing but a material body and its movements, or I must take, as true, that notion of a cause for your bodily actions, which in my mind always attends the concept of these actions. There is no logical difference in the mental processes by which are formed the notions of cause producing the movements of matter, whether the matter moved is dead, inorganic bodies, or living, moving, thinking, talking beings. Strictly speaking, our materialist philosopher has no right to believe in his own mind or thinking power, since none of the senses make him acquainted with it, but granting him so much in charity, he certainly has no right to believe any one else has a mind or soul, for it is only predicating from material movements a higher character of cause than he is called upon to recognize in the movements of ordinary material atoms or bodies.

§ 90. Another phase of this doctrine may be noticed. Motion is a passage of a material body of whatever size through a portion of space of whatever extent from one point to another, say from point A to point B. In this concept there is no element of an entity, of an essence or substratum apart from the body: it goes, it stops, and that is all we conceive of the motion. If immediately another body moves from point B. to point C. we notice a succession of time in the movements, but we cannot conceive of an element of the first motion passing into the second motion, for the moment we do we conceive a cause for the second motion which is contrary to the theory. In other words, if there be something in the first motion which survives it and passes into and determines or influences the second motion, then that something is what is known in other theories as a cause for the motion, as a force, and this particular theory inevitably falls. If its adherents think to be able, logically, to rid their system of the notion of force, and at the same time make the first motion, by reason of any property or attribute pertaining to it, a necessary antecedent to the second motion they are self-deceived. They must say the second motion occurs because it does; for if they say because the first motion occurs they at once by the expression and by the conception import into the first motion something they have already excluded by hypothesis. The theory can be likened to certain dances of some savage tribes described by travellers, where one set of dancers whirl on their toes till fancy or fatigue suggests that they stop, when immediately another set commences whirling, and when they cease a third take it up, and so on. Here nothing passes from the one set to the other, the whirling of the one in no way causes the whirling of the other; on the contrary, the determining principle and reason of each successive set of dancers starting on the cessation of the former set is found in the several sets of dancers themselves and not in the motion or cessation of motion of their predecessors.

So in the material universe. From the beginning there has been a continuous succession of motions in matter of all sizes from atoms up, the motion of one body sometimes succeeded by the motion of many, and the motion of many sometimes succeeded by the motion of one; but in every instance it has been a succession without a connection, causeless consequences from determineless antecedents, with no other relation than those of time and space. A moves when B ceases to move, but not because B did move. A's motion invariably succeeds B's, but is never determined or influenced by it. It follows, therefore, that whatever apparent purpose, plan or design there may be in nature is consequent upon the original constitution of matter which has determined its successive movements from the beginning. These movements have been as they have been and what they have been because matter is and has been constitutionally and essentially what it is and has been, and not because of any determining, constraining or restraining principle extraneous to or aside from its own elemental basis of existence. This clear-cut proposition should be distinctly grasped and firmly held, for any departure from it, however shadowy, is in just so much giving up the material theory and conceding to the doctrine of force or cause. In other words, either, there is or is not something diverse to both matter and motion which causes motion; there is or is not, both in thought and actuality, such things or rather such a thing as force or cause, and the notion which seems to prevail with some physicists of appropriating the office and receiving the usufruct of force or cause without admitting its existence as either actual or possible is most illogical, and always the progeny of confused conceptions upon the subject.

Stallo's Philosophy.

§ 91. Noticing next more fully than has been done (the fifth system) which may be called Judge Stallo's own, we find a very remarkable fallacy from a reasoner so subtile as he elsewhere appears. This is in taking the results of the most advanced scientific thought, and reasoning backward; assuming, not only that these results are absolutely true, but that they constitute the whole, the necessary truth, and that anything else is impossible, either actually or conceptually. Thus, accepting the Newtonian theory of gravitation, he first assumes that this is the result of a mutual and necessary interaction, second that all motion is of the same character, third that any other character of motion is impossible in fact, and fourth, impossible in thought. So with the notions of force and matter. Although elsewhere inveighing, as he well may do, against the metaphysical process of educing the essential character of things from the mental concepts of them, he nevertheless assumes, that, because in the process of thought the notions of matter and force cannot be divorced, or rather that the one thought is a necessary instrument in grasping the other, therefore the existence of the one is relative to that of the other; and further, because science has shown systems of interdependent and interacting bodies, he assumes that such bodies have no absolute existence independent of such relations.

Now if the latter proposition means anything, it means that earth could not exist without the sun, nor the sun without the planets which make up the solar system. While it is true that earth could not exist as it is without the sun, yet it is an assumption without logical reason to say that the extinction of the sun would cause the annihilation of earth and much more so to say that the destruction of all the planets would necessitate the destruction of the sun. True, science knows they are interdependent or at least interactive; but it is entirely conceivable that the character and course of that interaction might be reversed or entirely cease, and if such should be where is the logical cogency in saying the orbs themselves would cease to exist in thought or fact?

It is unknown, so far as astronomy has certainly determined, whether the sun is stationary in space, whether moving in a right line independent of all else save the retinue he carries with him, or whether by reason of a mutual interaction he is circling around some great central body; yet there is no difficulty in reasoning about the sun and considering him as an independent, stationary body, fixed at a certain point in space. However, if it shall be discovered hereafter that he is revolving around some central orb, Judge

Stallo, if consistent, will say that his existence, independent of such orb, is both impossible and unthinkable.

And this fact meets the Judge's proposition that motion is simply a relation between interacting bodies. Astronomers generally seem to think the sun is moving in a direct line towards the constellation, Hercules, but they do not claim that it is because of any attraction in that part of space. If they are right, his motion is an absolute, independent motion. Prof. Newcomb says the star Groombridge (1830) is moving in this direction with a velocity so great that it is impossible to account for it on the hypothesis of gravitation; in other words, that it is possessed of an independent, absolute motion, a thing which Judge Stallo says is impossible and unthinkable.

So the same argument applies regarding the notion of a fixed point in space. It is true that in thought, position or place can be located only by relating it to, or comparing it with, or measuring it from, some other place, and therefore, reasons Judge Stallo, "one place or position in space can have no existence except as related to some other place; there is no such thing as absolute space, and bodies have no absolute positions, but only relative." As already remarked, so far as known the sun is stationary. If so, according to the theory, it has a position relative to other astronomical bodies, but none in, and of itself; and if they were all destroyed, the sun being simply nowhere, would also necessarily cease to exist.

The trouble with Judge Stallo's theory is, that he takes the "scoffoldings of thought" as the essence of thought itself, and, more than that, assumes that as are those scoffoldings, so must the reality of necessity be. Because we can only think of matter as acted upon by force, and of force as acting upon matter, he assumes that the one can have no independent existence without the other; and yet this is the very metaphysical fallacy which he so severely criticises. Matter is revealed by force, he says; therefore, apart from force it has no absolutely, real existence—force is revealed by matter; therefore, apart from matter it has no existence. But more than this, he reduces force first to a rate of speed and then to an incident to the notion of mass.

§ 92. The fourth theory makes matter subject to the re-action of its own attribute, quality, or property, —a concept, almost, if not quite, impossible of realization in thought.

§ 93. The third theory is subject to this criticism: that if matter is but a static form of force, there is another form, the dynamic, so distinct that it may well be classed as a different species of existence, the one form filling the notions we entertain of matter, and the other those of force.

§ 94. The second is subject to the objection of hypostatizing the notion of potential energy, of which more hereafter.

§ 95. If we mistake not, the first theory will be found to fill the logical requirements of a natural and necessary cause for the activities of nature.

CHAPTER VII.

Conservation of Force.

CONSERVATION MODIFIED—DISSIPATION OF RADIANT HEAT—LIMITATIONS OF THOUGHT—DISSIPATION INVALIDATES SPENCER'S SYSTEM—DEFINITION OF ENERGY—POWER OF DOING WORK—TWO KINDS OF ENERGY, ACTUAL AND POTENTIAL—STONE THROWN UP—ENERGY CONSERVED—DRAWING A BOW—COMBUSTION—STEAM ENGINE—TRANSFORMATION OF ENERGY—A CONTRADICTION—CREATION AND ANNIHILATION OF ENERGY—STEWART AND TAIT.

Loss of Heat and Light Radiations.

§ 96. The doctrine of conservation has been greatly modified since its first promulgation. Physicists have observed that radiant heat and light are constantly thrown off into space, not only by the sun and other astronomical bodies but by all objects on earth's surface. The sun is said to be burning out like a candle, and even the length of time it may last as a fountain of light and heat has become a matter of speculation. Prof. Langley says: "At present our science teaches us to look for a period in the far distant future when our sun's fires shall become extinct and earth a frozen orb."

Mr. Spencer says: "But there is another species of equilibration going on in the solar system, with which we are more nearly concerned—the equilibration of that molecular motion known as heat. The tacit assumption hitherto current, that the sun can continue to give off an undiminished amount of light and heat through all future time, is fast being abandoned. Involving as it does, under a disguise, the conception of power produced out of nothing, it is of the same order as the belief that misleads perpetual-motion schemers. The spreading recognition of the truth that force is persistent, and that, consequently, whatever force is manifested under one shape must previously have existed under another shape, is carrying with it a recognition of the truth that the force known to us in solar radiations is the changed form of some other force of which the sun is the seat; and that by the gradual dissipation of these radiations into space, this other force is being slowly exhausted." *First Principle, p.* 493.

Prof. Young says: "According to Newcomb, if the sun maintains its present radiation, it will have shrunk to half its present diameter in about five million years at the longest. As it must, when reduced to this size, be eight times as dense as now, it can hardly then continue to be mainly gaseous, and its temperature must have begun to fall. Newcomb's conclusion, therefore, is that it is hardly likely that the sun can continue to give sufficient heat to support life on the earth (such life as we now are acquainted with at least) for ten million years from the present time.

"It is possible to compute the past of the solar history upon this hypothesis somewhat more definitely than the future. The present rate of contraction being known, and the law of variation, it becomes a purely mathematical problem to compute the dimensions of the sun at any date in the past, supposing its heat radiation to have remained unchanged. Indeed, it is not even necessary to know anything more than the present amount of radiation, and the mass of the sun, to compute how long the solar fire can have been maintained, at its present intensity, by the process of condensation. No conclusion of geometry is more certain than that the contraction of the sun from a diameter even many times larger than that of Neptune's orbit to its present dimensions, if such a contraction has actually taken place, has furnished about eighteen million times as much heat as the sun now supplies in a year ; and therefore that the sun cannot have been emitting heat at the present rate for more than that length of time, if its heat has really been generated in this manner. If it could be shown that the sun has been shining as now for a longer time than that, the theory would be refuted ; but if the hypothesis be true, as it probably is in the main, we are inexorably shut up to the conclusion that the total life of the solar system, from its birth to its death, is included in some such space of time as thirty million years. No reasonable allowance for the fall of meteoric matter, based on what we are now able to observe, or for the development of heat by liquefaction, solidification, and chemical combination of dissociated vapors, could raise it to sixty million.

"At the same time, it is of course impossible to assert that there has been no catastrophe in the past —no collision with some wandering star, endowed, as Croll has supposed, like some of those we know of now in the heavens, with a velocity far surpassing that to be acquired by a fall even from infinity, producing a shock which might in a few hours, or moments even, restore the wasted energy of ages. Neither is it wholly safe to assume that there may not be ways, of which we yet have no conception, by which the energy apparently lost in space may be returned, and burned-out suns and run-down systems restored ; or, if not restored themselves, be made the germs and materials of new ones to replace the old.

"But the whole course and tendency of Nature, so far as science now makes out, points backward to a beginning and forward to an end. The present order of things seems to be bounded, both in the past and the future, by terminal catastrophes, which are veiled in clouds as yet impenetrable." — *The Sun, p.* 276.

Prof. Lovering says: "Thompson calculates that, within the historical period, the sun has emitted hundreds of times as much mechanical energy as is contained in the united motions of all the planets. This energy, he says, is dissipated more and more widely through endless space, and never has been, probably never can be, restored to the sun, without acts as much beyond the scope of human intelligence as a creation or annihilation of energy, or of matter itself would be."—*P. S. M., Jan.*, 1875, *p.* 318.

The astronomer Robert S. Ball says: "We therefore conclude that the sun's heat is being squandered with prodigal liberality." —*P. S. M., June*, 1883, *p.* 247.

Haeckel says: "The day will come when man no longer can say, 'Lo, Homer's sun sends down his beams upon us;' a day when the earth, over and over ice-clad, will travel sluggishly around the sun, whose fires will then burn only with a ruddy glow; a day when, just as in the beginning, light was, because the first eye opened, so 'Darkness will be,' because then the last eye closes."—*P. S. M., Aug.*, 1878, *p.* 392.

Limitations of Knowledge.

§ 97. Now as to what becomes of such of the radiations of light and heat as do not in their course through space impinge upon other bodies, there is not the least scintilla of information, and, therefore, scientists have no kind of warrant to make any affirmation about it. All we know is that it is apparently lost to the material universe as we know it, and all our reliable computations upon the quantity or constancy of energy in the universe must be made on that basis. Whether it is ever in any way returned to its original sources, or whether it in any other way becomes again a factor in the processes of nature, we know not, and have no right to presume the one way or the other any more than we have to presume anything else which we neither know nor can know anything about. Whether it is gathered up and utilized in some other universe, or some other system of nature, we know not; whether it wanders on in radiant lines through infinite duration, we know not; whether in the abysms of space it meets with oblivious extinction, we know not. The latter proposition will perhaps be controverted. There are those who claim that we necessarily know matter and force as eternal because we cannot form a conception of their annihilation. But neither can we of their eternality. Only a mind that can grasp infinity can do the latter. Only a mind which can grasp the nothingness which bounds existence can do the former. Finite mind can construe in thought neither absolute infinity nor absolute zero. One is as unthinkable as the other. We have to accept things as the laws of mind compel us to think them. These laws compel us to think the present real existence of objective nature and forbid us to think it either out of existence or as continuing parallel with eternity, and so we do think it, somewhere, it may be anywhere, between these unthinkable extremes. So we do think it, and so it is, and must be to us. Whether it be so as an absolute fact, that is, to the Infinite Mind, we do not and cannot know. This is but a different statement of Hamilton's law of the "Conditioned." And there is a great deal of metaphysico-scientific fallacy founded on its violation. Undemonstrated and undemonstrable hypotheses are assumed as facts for the basis of whole systems of philosophy.

But it should be enough for us to go along with the facts, and stop where they stop. So governing ourselves, we find that heat and light go out into space in great floods, becoming utterly untraceable to us, ceasing utterly, so far as we know, to be accountable quantities or factors in nature. Therefore, whatever may be the real facts as apprehended by the Divine Mind, to us, in the arithmetic of the universe, they must be subtracted as quantities which were but are not.

§ 98. Therefore, two of the original propositions of Conservation, that "no old force is ever lost", and that "the quantity of the forces of nature remain constant," drop out and leave only the two: "No new force is ever generated," and "the several forces correlate with each other."

And this contradicts Mr. Spencer and invalidates the basis of his whole system. From nebulæ, star and sun, planet, earth, and satellite, incalculable measures of heat-energy are continually radiated into space, never again, so far as we know, to become factors in the universe, lost to every means of calculation and identification we can ever hope to attain to, gone from us forever. Therefore, it cannot be true that all energy persists—the most that can be true is that *some* energy persists.

Energy.

§ 99. While the several physicists so largely quoted from in Chapter IV. differ very widely amongst themselves regarding the nature of force, thus establishing the fact that force has no particular scientific *status*, or rather that scientists find it a factor very hard to reconcile with the theory of conservation, they all, excepting Grant Allen, agree pretty well amongst themselves and with Mr. Spencer regarding energy. Energy is conserved; energy is the power of doing work, and work is the production of change or motion in matter. Then that which is conserved —which persists—is the power of causing change in matter, for there can be no change without motion. What does "power" as here used signify? Evidently ability or capacity. Then we have *the ability of doing work*, or *the capacity of doing work*, or, *the power of doing work persists.* Now it is submitted that whichever word is taken, power, ability, or capacity, it must necessarily represent an attribute of *something.* The *power* to do means that *something* has the *power* to do; the *ability* to do means that *something* is *able* to do; the *capacity* to do means that *something* possesses the *capacity* of doing. That is to say (if language is given its proper and ordinary signification) when it is asserted that what persists is that energy which is the power of doing work, it means that what persists is the attribute of *something;* and when it is gravely proposed to submit this energy to quantitative measurement, it is asserting that a certain attribute or quality of some *unnamed*, and so far as we are as yet informed, *unknown something* is subject to weight, measure and comparison. As Prof. Tait understands using "mere names" as factors in arithmetic, no doubt he knows how to weigh and compare the qualities of *unnamed*, if not *unknown*, existences, but the illogical, aye, impossible character of the proposition, only needs stating, to be fully apprehended by the common mind.

§ 100. But what we now need to do is to ascertain, if it may be, the exact notion which physicists entertain of this conserved energy. To do so we must examine three principle cases, that connected with gravity, that dependent upon elasticity, and that growing out of chemical reactions. In the outset, it must be remembered that the scientists all postulate two species of energy, actual energy and potential energy. Actual energy is the power of doing work possessed by a moving body by virtue of its present motion, or by some force by virtue of its present action upon matter. The first definition seems to be applicable to the first two cases above, and the second definition to the third case above. Potential energy, otherwise called energy of position, is the power of doing work possessed by a body by virtue of its position in space relative to some other body—the term body being understood to include molecules and atoms.

§ 101. To illustrate the first case: A man has energy—whether actual, potential, or both, is not clear—by reason of his contractile muscles which gives him "power to do work" by leaping into the air, or by hurling a stone aloft. In the latter instance, the work he does on the stone gives it actual energy, which enables it to do work by rising from the earth to a certain height, where, if it is caught, say on a cliff, it will remain with potential energy; that is with the power of doing work by falling back to the ground again when pushed off. In doing the work of falling it again takes on actual energy, and upon impact with the ground communicates the same in the form of heat, and is itself left without energy of any kind. And it is to be noted that the actual energy with which the stone ascends is exactly equivalent in quantity to the potential energy possessed by it on the cliff, to the second content of actual energy it obtains by the fall, and to the heat generated by the fall. That is to say, if the heat could be all gathered up and turned again upon the stone it would send it to the same spot on the cliff, and another fall would generate the same amount of heat. It is to be noticed further, that the time of ascent is precisely the same as of descent; that the velocity at the moment of starting up is the same as at the moment of return; and that the speed is precisely the same at any particular point in the passage either way. Not only so, but the muscular energy of the man's arm imparted to the stone is the *same identical* actual energy which carries the stone upward, the *same* which in potential form it possesses while resting on the cliff, the *same* which, again assuming actual form, carries it to the ground, and the *same* which, upon impact, takes the form of heat. It is the *same* essential principle persisting throughout as muscular energy in the arm, as actual energy in the ascending stone, as potential energy in the resting stone, as actual again in the falling stone, and as heat after impact.

§ 102. In the second case the muscular energy of the arm does work in drawing the bow; this is transformed into potential energy in the bent bow, and again into actual energy in the speeding arrow, and then into heat when the arrow strikes the target,—the same in equivalence and in essence throughout.

§ 103. In the third case there is in the particles of coal, by virtue of their affinity for oxygen, a potential energy, which in combustion becomes actual in the form of heat, and this acting upon water may again become potential in steam, which in turn may do work upon the piston of the steam engine. The piston may do work by moving connected machinery, and this may do work in manufacturing fabrics, until finally the actual energy is all converted back into heat. And now again, if this heat could all be gathered up it would be the same in essence and quantity with that originally developed in the combustion of the coal. Or this original heat-energy from the union of the oxygen and coal may be made to do work by hurling up the stone as in case one, and if such could be done without any waste of heat anywhere on the round, the heat developed upon impact of the stone with the ground would be precisely the same in quantity and identity of existence with that originally obtained from the coal in its union with oxygen.

§ 104. This seems to be, in brief, a statement of the doctrine held by physicists generally. But in one important particular to which reference will be made after quoting from Balfour Stewart, Balfour Stewart and P. G. Tait seem to differ from the others and from themselves. Says Mr. Balfour Stewart: "Thus, as the stone mounts up, there is *no annihilation* of energy, but merely the transformation of it from actual energy to that implied by position; *nor have we any creation* of energy when the stone is again on its downward flight, but merely the re-transformation of the energy of position into the original form of actual energy."—*Elementary Physics, p.* 110.

But say Mr. Balfour Stewart and Prof. P. G. Tait: "In other words, while one form of energy becomes changed into the other—potential into kinetic and kinetic into potential—or one species of either into another;—yet each change represents at once a *creation* of one kind of energy and a simultaneous and equal annihilation of another, the total energy present, as we have already said, remaining forever unaltered."—*Unseen Universe*, *p.* 114. Now, it is a little hard to understand how a *change* of one form into another can at the same time be an *annihilation* of the one form and *creation* of the other, and perhaps these distinguished writers do not mean what they say; but there it is, and if taken literally, there is an end of the discussion, for conservation is out of the question.

§ 105. But getting back to the consideration of case one above, it may be noted that equivalence in quantity is very slight, if any, evidence of identity of essence. That 4 x 6 dollars=3 x 8 dollars is no evidence that the first 24 dollars are identically the same coins as the last 24 dollars. Neither does identity in part necessitate the conclusion of identity throughout. Though it be admitted that the 4 x 6 dollars and the 3 x 8 dollars are the same coins, it does not follow that 2 x 12 dollars are the same coins, though equivalent in number and value.

§ 106. Having spent so much time and space in prospecting the ground of conservation as encumbered by the theories of various philosophers, and sifted out as best we could the meaning of their various relevant definitions and the scope and fundamental principles of their several systems, the more serious aspects of the discussion will be taken up.

Force a Real Something.

It has been seen that Mr. Spencer predicates the *persistence* upon which he founds his great system of philosophy upon *force*, and that he makes *force* a very real existence. And also, that while it is true that Prof. Tait, Mr. Taylor, and others make it a mere name, or would abolish it altogether, they propose in its stead "energy" under a definition which makes it an attribute or property of *something*; some very real reality which must be present as *the* substance or substratum wherever that attribute is found. So that, in fact, they tramp in a circle and establish the reality of force by the very process of logic to which they resort to accomplish its abolition.

§ 107. Then for a basic principle for the argument, we have the admission direct by Herbert Spencer, Balfour Stewart, Prof. Thurston and Grant Allen, and indirect by Prof. Tait, Mr. Taylor and Mr. Carpenter that force is not a mere name, a something subject to annihilation by the decree of a few scientists, but a very definite and positive existence to be counted upon and accounted for in every physical discussion.

CHAPTER VIII.

Kinetic Force and Pressure.

FORCE A REAL SOMETHING—ENERGY A PROPERTY OF SOMETHING—TWO MODES OF FORCE—PRESSURE AND KINETIC FORCE—PRESSURE DEFINED—AN EFFORT TO PASS INTO KINETIC FORM—ILLUSTRATIONS—DOING WORK—KINETIC FORCE CHANGING INTO PRESSURE—TIME THE MODIFYING ELEMENT—IMPACT AND HEAT—FORCES KNOWN BY THEIR BEHAVIOR — ILLUSTRATIONS — COMPARED WITH MUSCULAR FORCE—ESSENTIAL PRINCIPLE IN PRESSURE—CONTINUALLY EXPENDED AND CONTINUALLY RECEIVED—THE PRINCIPLE MISSED BY PHYSICISTS.

§ 108. On one important proposition it is conceded that the scientists are right. Force manifests itself in two principal modes—pressure and kinetic, molar, moving, or motion-producing force. But we can go together but quite a little way, for it cannot be conceded that these diverse manifestations are different species of force as contended for, nor even essentially different modes of force, but the same mode of the same existence, only differently conditioned or circumstanced in action.

§ 109. Indeed, so far from kinetic force and pressure being incomparably unlike, as held by Profs. Stewart and Tait, they are but accidents of the same modes of force. Kinetic force is exhibited by translation of matter through space. Pressure is force passed through a body. A body is constituted of particles held together and held apart by molecular forces. Pressure is resisted by the molecular forces of the body. If these forces are of sufficient magnitude to make the resistance effective, the pressure is passed on through them. If their moment is insufficient, they give way, motion takes place in the pressing body, and kinetic force is exhibited. That is, pressure becomes kinetic force by reason of the fact of overcoming the resistance of opposing cohesion in the resisting body.

The character of the pressure makes no difference. It may be the pressure of gravity or weight; it may be muscular pressure, as of the hand; it may be elastic pressure, as of a spring, a compressed rubber ball, compressed air, or steam. Or it may be a pull as of the hand by a cord, or of a stretched rubber string, or of a magnet. In either and all the cases the pressures or tensions are alike in this: that they remain such only while they are opposed by the cohesive forces in the resisting bodies, and that at the moment the opposition gives way they are each and all converted into kinetic forces, producing actual motion.

In all kinds of pressure the pressing force is all the time struggling to pass into the kinetic mode of action, to pass from the state of pressure into the state of motion, and that struggle can cease only when either the result is accomplished or the pressure force ceases to act. In the nature of things there can be no pressure without just this struggle.

§ 110. Now, in illustration, let us try some instances. When, in Prof. Tait's example, the man lifts the hundredweight from the ground, what does he do? He overcomes the pressure of 100 pounds which the weight exerted on the ground, does he not? When he lifts at the ton with the same tension, what does he do? Does he not lessen the pressure of the ton just 100 pounds so as to make it 1900 pounds instead of 2000 pounds? Is not the same amount of pressure overcome in both cases? In one it happens to be all of it, and in the other only a part. Yet we are told that the phenomena is too unlike for comparison. If a man should eat the half of an apple now and a whole apple an hour later, would it be said that the phenomena are too diverse for comparison? A very frivolous query, truly; but to the ordinary mind the one proposition is as sensible and logical as the other!

§ 111. Another instance: One of your team is quick and the other slow. You give the word, and the quick horse throws all his strength against the collar instantly, but the van does not move; all the stress of his energy is insufficient to overcome the obstructing forces. You repeat the word, the other horse moves forward and the load follows. The pull of the first horse was stress or tension only. When this tension is doubled by adding the pull of the other horse, the result is forward motion. And we are told that the phenomena in the two cases are incomparably unlike.

§ 112. You lift at a sack of grain with one hand, it does not move; your muscular energy exerts a tension on the sack, no more. You double the tension by lifting with both hands, and the sack rises. And we are told that these actions are entirely unlike, of different species, not explicable upon the same principles.

Again, you wish to hoist, say a box of goods, aloft. You throw a rope over a pulley and exert all your muscular strength at the other end. The box does not move. You fasten a weight, say of two hundred pounds to the rope and swing it free; still the box moves not. You now take hold of the rope and add the strength of your pull to that of the weight and the box goes up. Here your individual strength but exerted a tension against the gravity of the box; the gravity of the weight acting alone, but did the same. However, the tension of your muscular energy and that of the gravity of the weight united causes the elevation of the box.

§ 113. Now, the reason assigned why these multiple exertions of force are incomparable to single exertions is, that the former do work and the others do not. Doing work is producing motion. The former do work because they are large enough to overcome the resisting pressure of gravity; the latter fail to do work simply and only because they are too small to overcome the same pressure. The tensions are alike, exerted in the same direction by like agencies, against like obstructions, with the only reason for a difference in results being the difference in quantity of energy exerted, and yet the same philosophers who can readily calculate the products of mere names into velocities, and can find a standard of measurement between separation and motion, tell us that it is simply absurd to attempt a comparison between these single and double exertions of energy! And this almost causes us to suspect that a mathematics which leads to such results must itself be near of kin to absurdity.

§ 114. Not only so, but kinetic force, when resisted, is to a greater or less extent passed or metamorphosed into pressure. When an anvil is struck by a hammer a part of the molar force of the blow is converted into pressure and passed through the particles of the anvil. And so in every impact or concussion. Some of the force goes into the impeding body; if insufficient to set up molar motion in such body, a part, at least,of the force passes into and through its particles in the form of pressure.

§ 115. Time seems to be the modifying element between impact and pressure. When force passes from one body to another without any appreciable accumulation in time it is pressure; when concentrated in time it is impact. One body may rest upon another for ages without crushing it; a very much smaller body, by impact, occupying an inappreciably short time, may prove irresistible. If the time of impact be doubled perhaps the force will be successfully resisted. It seems that pressure can be conveyed away only so fast; force communicated faster becomes impact,and its crushing effect is very much increased. That is, pressure has a time-rate, and collision in quicker time than such rate is impact. Whether all pressure has the same time-rate cannot be stated. The time-rate pressure in gravity is just equal to the reception of gravitative force. By reason of this fact gravity does not accumulate in supported bodies, as will be seen in the discussion of Gravitation.

§ 116. Prof Tait says: " If any one presses a stone with his finger, his finger is pressed with an equal and opposite force by the stone.—*Recent Advances in Phys. Science, p.* 355.

And physicists say that if a book presses on a table upon which it is lying, the table presses with equal force on the book; and if a stone presses on the ground, the ground presses on the stone with equal power.

§ 117. A very little reflection will suffice to show that this view is altogether erroneous. As we have seen, pressure is a continuous effort of the pressure-force to pass into kinetic form and produce molar motion. The pressure of the finger is an effort to produce forward motion in the stone, which effort will be accomplished whenever the pressure force is of sufficient moment to overcome the forces which hold the stone in place. But there is no effort by any force in the stone to produce opposite molar motion in the finger. No force passes from the stone to the finger tending to push it off or set up kinetic motion in it. So the book which presses upon the table by reason of gravity, would assume downward kinetic motion but for the obstruction offered by the table. As it is, the gravitative force in the book, struggling to carry it downward against resistance, passes into the table, tending to drive it downward also, and which it would accomplish, but for the resistance of the supports. Now nothing passes from the table upward into the book: the book receives no tendency or impression to move upward. A flower laid under the book will be crushed by reason of the molar motion set up in the book by its pressure force, but the same flower laid upon the top of the book will receive no impression, simply because there is no pressure in that direction, Prof. Tait and the Scientists, generally, to the contrary notwithstanding.

And this would seem to be another very patent instance of a theory being set up—not only without the support, but in the very teeth of facts.

§ 118. It is true that scientific books are full of the statement that in all cases of impact between inelastic bodies the whole of the molar force is metamorphosed into heat. But that cannot possibly be true in any instance. More or less heat is developed upon every such impact, but a part of the force is always converted into vibratory motion in particles of the colliding bodies, and a part is always passed off as pressure. It is not known that science has as yet discovered any method of segregating and measuring the relative quantities of these several characters of force developed at every impact, and, indeed, it is not much likely to make the effort so long as it contends that the only result of impact is heat.

§ 119. There is another aspect or characteristic of pressure-force which can be best discussed after the citation of several illustrations. But first, by referring to §§ 110–112 the observation will be well enforced that we can know forces only by their behavior or conduct with matter. If we see two different forces comporting themselves precisely alike with the same or like material bodies, we have every assurance possible in the case that they are of the same character.

§ 120. You may weigh out a hundredweight of sugar or other commodity on a grocer's scales or balances. A man may press down with hands till the beam marks the same figure. A hundred pound stone may hold down the long end of a lever. The hands of the man may do the same. You may weight down a steel spring or stretch a strong rubber cord or run clock work with the weight of the same stone. The hands of the man may do all this to the same degree and extent. You cause water or gas or a coiled spring to press out the sides of a tank with a tension of one hundred pounds. The man with hands and feet and head may do the same. With a very small portion of gunpowder you may drive a ball out of the muzzle of a rifle. A boy with his hands may do the same thing from his pop-gun

§ 121. We have a right to assume, then, that these various force-pressures are similar, or of the same character, and, like the pressure-forces exerted by the man and boy, in so far as the capacity of producing the same results require them to be alike.

§ 122. Now what is the force exerted by the man? It is called muscular force, andresults directly from a contraction of the muscles and indirectly from the consumption of food and the breathing of oxygen. But it is not in its origin, but in the manner and results of its action or expenditure that we may expect these physical pressure-forces to be like it. And what is there peculiar in the action of this muscular pressure-force? Why, that it absolutely expends itself—goes out into the resisting medium as long as the pressure is continued, or until utter present exhaustion of the present source, it may be; that is, till exhaustion by fatigue.

§ 123. The time in which it will so exhaust itself will depend upon the relative supply on hand and the rapidity with which the man's recuperative system works a new supply. That is to say, so long as the man wills he can keep up the pressure until his strength is utterly exhausted by impartation; but while being given out, it is continually re-supplied, and the relative rapidity of the exhaustion and re-supply determines the length of time he can continue the pressure without rest. But he can, at any moment, cease to give out a part or all of such muscular strength, and that moment the pressure will cease in the same degree.

§ 124. Now the point to be observed is that the very existence of the pressure depends upon the giving out of force or sending it into the resisting medium; and that this impartation of force is continuous as long as the pressure continues; that the pressure means just this, and has its very essence in just this. The man imparts or pushes his muscular force into the obstruction, and when such impartation ceases either by the volition of the man or his muscular exhaustion, the pressure ceases.

§ 125. That which is the essence of pressure-force in this case must be in every case. It must be a continuous passing into the resisting medium. We have already seen (100) that pressure is a continuous struggle to pass into kinetic motion, a struggle which is ineffectual so long as it is in *quantum* inferior to the opposing forces; but in the struggle it is all the time going out into the obstructing medium. Balfour Stewart's stone on the cliff continually sends down pressure-force through the rock strata towards the center of the earth. If at any moment it should cease to do so, it would that moment lose all weight. So with everything else on the earth's surface possessing weight.

§ 126. The gas in the tank for no moment ceases its pressure, and in its pressure it continually imparts pressure-force to the sides of the tank whose molecular cohesive forces are as continuously put upon strain to resist it, though sometimes the gas-pressure may so far overbalance the other as to pass into kinetic force, rending the walls of the tank. So with steam or a coiled spring in a cylinder. A pressure-force is continually imparted to the walls of the cylinder, and in the steam cylinder to the end of the piston, struggling to become kinetic force, which it may do by driving out the piston or rending the cylinder.

§ 127. But as we have seen in the exertion of muscular force there is more than all this implied in the behavior of pressure-force. Not only is it continually expended, and does it continually pass into the obstructing material in its struggle to metamorphose into molar force, but it is and must be resupplied. The waste has to be kept up, the expenditure made good, else the pressure will cease. Should there ever come a moment when the stone on the cliff should fail to be resupplied with the pressure-force the moment before passed downward, in the same moment it would lose all weight. And so with the pressure of the gas, the steam, and the coiled spring; the continuous expenditure has to be continuously kept good. It is the very essence of pressure-action. It is not possible that pressure should exist without it.

Now these are facts, facts of experiment and common observation. They may be verified in a thousand ways. They are so common, indeed, as not to attract attention. Perhaps it is because they are so common and ordinary that they have been veiled by far-fetched theories. But as to whence comes this re-supplying force to continuously exhausting pressure, the reason is not obvious, but for the present, at least, must be left to theory. All we now know, and, perhaps, all we can ever know, is that in pressure, force is ever going out and passing off, and that the waste must in some manner be kept good or else the pressure will cease. And here, it would seem, that new forces do continually come into recognition, and that another basis of Conservation is discredited.

§ 128. Heretofore physicists have not grasped the idea. They have not in thought analyzed the pressure process. They have not formulated definite notions of how forces have to behave to produce pressure. They have assumed that a force can give out force-virtue without expending itself in the doing. They have, indeed, made pressure-force action like muscular-force action in man, so far as the expenditure of force is concerned, but they have failed to follow the analogy to the supplying of the loss. With them pressure-force is like a strong man who would never tire, never fatigue, and never need to re-supply wasted strength by eating, breathing or otherwise. Suppose such a man exerting any particular muscular pressure ceaselessly and indefinitely and you have the scientific notion of pressure-force.

And because the true notion of pressure-force has been missed the whole accepted theory of gravitation is wrong. Had it been clearly perceived what it necessarily takes to constitute the pressure-force exerted in weight, the whole correct doctrine of gravitation would have opened out at once. Nor could the doctrine of Conservation ever have found foothold if the true notion of pressure-force had been seen, for it would have been apprehended at once that the force sent into the resisting obstruction must be continuously supplied from some source so long as the pressure is kept up, and, as in gravity, there is no known physical source from which it can be drawn, it must come from some source outside of what we know as the physical universe, and be, in fact, a new force continually.

Let it here be recalled that this explanation involves three elementary principles:

1. That in pressure the pressure-force is all the time struggling to pass into kinetic mode; that is, to carry bodily forward through space, the mass which it momentarily occupies.

2. That failing in this, by reason of deficiency in quantity to overcome the resisting obstruction, it continuously passes out of the mass of its momentary occupancy into and through the obstructing body.

3. That so long as the pressure is kept up, the body from which it passes into the obstructing medium must be continuously resupplied with pressure-force, to make good the loss, from some source, as yet, unascertained by science.

Force and Inertia.

§ 129. It now becomes necessary to discuss force in a different aspect, preparatory to which a few observations will be relevant. The first is that while mathematical formulæ and computations have everything to do with the numerical and quantitative relations of force, energy, matter, motion and velocity, they have and can have nothing whatever to do with the essence of that *something*, let it be called what it may, which determines, makes, or causes motion.* Whether a piece of wood is oak or ash, whether a lump of mineral is lead or zinc ore, whether the contents of one jar is wine or water, or of another, common air or hydrogen gas, are not and cannot be mathematical questions. No more can be the question as to what induces, makes, or causes motion. This is insisted upon, because Prof. Mayer and others are disposed to subject these matters to the test of mathematical formula.

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* A poet has truly said: "The mathematics are the science of form and quantity; mathematical reasoning is merely logic applied to observation upon form and quanity."—*Poe.*

§ 130. In the next place it may be remarked that in formulating his laws of motion and in discussing the laws of force and inertia, Newton had in view the motions of a "conservative system of bodies," like the solar system, wherein the motions of forces acting upon each body were considered as relative to the motions of force acting upon the others. Now in considering the essential character, origin, and behavior of forces disparate from any supposed relativity, Newton's laws are only partially applicable, and, when applicable at all, frequently only in modified form.

§ 131. But physicists say all motion is relative, and that "Forces always occur in pairs, every exertion of force being a mutual action between two bodies."—*Deschanel*, *Nat. Philosophy*, *p.* 45.

Now, although this may be generally true, it is not universally so. The radiations of heat and light are certainly exceptions. According to Prof. Newcomb, the motion of the star Groombridge, 1830, is an exception, and, for aught we know, there may be innumerable exceptions of the same kind in the sidereal universe. All the orbital motions of the planets are, in certain aspects and to a certain extent, to be hereafter examined, exceptions. It is true, also, that, although in every projectile motion there is in the initiatory impulse equal tension in opposite directions, yet, from the originative movement on it is an unrelated and independent motion, the product of an unrelated and independent *motion-maker*, until overcome and exhausted by resistance of some kind or other.

So that, while it is true nature cannot be understood without a knowledge of the laws of relative motion—of the motions of "a conservative system," it is equally true that it cannot be understood without a knowledge of independent or absolute motion. And the latter, being simpler, naturally comes first in order of investigation, just as addition comes before the cube root in arithmetic. The notion that "all motion is relative, and that all force occurs in pairs" is essentially a materialistic notion. It grows out of the idea that force is an attribute of matter, and always proceeds out of one mass of matter to act on another, while a reciprocal force proceeds out of the latter to act upon the former. Because we have no other means of becoming acquainted with force except as we observe its behavior with matter, it is assumed that it has no existence disparate from matter. Because, generally, in those modes of force known as *attractions*, there are reciprocal manifestations of force, and because in the initiation of impulsive motions, there are equal exertions in opposite directions, it is assumed that forces can exist only in pairs. But this mode of reasoning is essentially defective and vicious. It is assuming that the absolute essence of existences has the same limitations as our experiential knowledge of them, which is a very bold assumption. Not only so, but it ignores entirely such independent motions as that of the star Groombridge and the radiations of heat and light.

§ 132. From the definitions it will be seen that, in a sense, inertia and force are reciprocals, and, therefore, any theory of one involves a counter-theory of the other, and the discussion of one includes the discussion of the other.

Now, there are two opposite theories of these principles. The first to be noticed is that of Galileo, Newton, and scientists generally. It supposes that inertia is that property of matter which renders it susceptible to the action of force in initiating motion, or rather, by reason of which matter is entirely indifferent to rest or motion, and either rest or motion equally natural to it. On the contrary, it supposes the only action of force on matter is to initiate or set up motion in it on the one hand, or to stop it on the other; that, while force is necessary in the starting of all motion, inertia alone carries it forward until it is resisted or stopped by other force.

§ 133. The other theory, held by Kepler, is that inertia is simply a negative quality in matter indicating its capacity of being acted upon by force, while force is necessary to the carrying forward of motion as well as to the starting of it; that inertia neither initiates nor continues motion, but, on the contrary, all motion is initiated and carried on by force present in, and continuously acting upon the moving body; and that when such force is withdrawn or ceases to act all motion ceases of necessity.

It may be observed that this difference of theories lies at the very basis of all physical science and philosophy. If the received notions are correct that science and philosophy are one thing, if incorrect quite another. Which theory is correct? is therefore a question of immense importance in science and philosophy, and one demanding the very severest scrutiny and thought.

§ 134. The popular view is stated by scientists and writers on natural philosophy as follows:

Thus, Dr. Whewell, in speaking of the Greek School of Dynamics, (*History of Inductive Sciences, Vol.* 1, *p.* 313,) remarks that, "they confounded the causes which *produce,*' and those which *preserve,* motion." Again, on page 324, he says: "The first law of motion asserts that the motion of a body, when left to itself, will not only be uniform, but rectilinear also." On page 320, he says: "But the most common mistake of this period was, that of supposing that as a force is requisite to move a body, so a perpetual supply of force is requisite to keep it in motion. The whole of what Kepler called his 'physical' reasoning, depended upon this assumption. He endeavored to discover the forces by which the motions of the planets about the sun might be produced; but, in all cases, he considered the velocity of the planet produced by, and exhibiting the effect of, a force which acted in the direction of the motion. Kepler's essays, which are in this respect so feeble and unmeaning, have sometimes been considered as disclosing some distant anticipation of Newton's discovery of the existence and law of central forces. There is, however, in reality, no other connection between these speculations than that which arises from the use of the term *force* by the two writers in two utterly different meanings. Kepler's Forces were certain imaginary qualities which appeared in the actual motions which the body had; Newton's Forces were causes which appeared by the change of motion:

Kepler's Forces urged the bodies forward; Newton's deflected the bodies from such a progress. If Kepler's Forces were destroyed, the body would instantly stop; if Newton's were annihilated, the body would go on uniformly in a straight line. Kepler compares the action of his forces to the way in which a body might be driven round, by being placed among the sails of a wind-mill; Newton's Forces would be represented by a rope pulling the body to the centre. Newton's Force is merely mutual attraction; Kepler's is something quite different from this; for, though he perpetually illustrates his views by the example of a magnet, he warns us that the sun differs from a magnet in this respect, that its force is not attractive but directive."

§ 135. Prof. Newcomb says: "The great misapprehension which possessed the minds of nearly all mankind till the time of Galileo was, that the continuous action of some force was necessary to keep a moving body in motion. That Kepler himself was fully possessed of this notion is shown by the fact that he conceived a force acting only in the direction of the sun to be insufficient for keeping up the planetary motions, and to require to be supplemented by some force which should constantly push the planet ahead. The latter force he conceived might arise from the rotation of the sun on his axis. It is hard to say who was the first clearly to see and announce that this notion was entirely incorrect, and that a body once set in motion, and acted on by no force, would move forward forever—so gradually did the great truth dawn on the minds of men. It must have been obvious to Leonardo da Vinci; it was implicitly contained in Galileo's law of falling bodies, and in Huyghens's theory of central forces; yet neither of these philosophers seems to have clearly and completely expressed it. We can hardly be far wrong in saying that Newton was the first who clearly laid down this law in connection with the correlated laws which cluster around it. The basis of Newton's discovery were these three laws of motion:

"First Law. A body once set in motion and acted on by no force will move forward in a straight line and with a uniform velocity forever.

"Second Law.—If a moving body be acted on by any force, its deviation from the motion defined in the first law will be in the direction of the force, and proportional to it.

"Third Law.—Action and reaction are equal, and in opposite directions; that is, whenever one body exerts a force on a second one, the latter exerts a similar force on the first, only in the opposite direction."—*Popular Astronomy, p.* 75.

§ 136. Prof. C. S. Pierce *of the "Coast Survey"* says:—"If bodies were left to themselves, without the intervention of forces, every motion would continue unchanged, both in velocity and in direction."—*Popular Science Monthly, January*, 1878, *p.* 295.

§ 137. Prof Deschanel says:—"A body not acted on by any forces, or only acted on by forces which are in equilibrium, will not commence to move; and if it be already in motion with a movement of pure translation, it will continue the velocity of the translation unchanged, so that each of its points will move in a straight line with uniform velocity. This is Newton's first law of motion."—*Nat. Philosophy, p.* 41.

§ 138. Judge Stallo says:—" Newton distinguished two kinds of force—the force of inertia (*vis inertiæ,*) and impressed force (*vis impressa*). The former alone, according to him, is *vis insita, i.e.*, inheres in matter; while of the latter he expressly says—that this force consists in action alone, and does not abide in the body after action."—*Modern Physics, p.* 39.

§ 139. The received doctrine of force, as expressed in Newton's First Law of Motion, lies at the very bottom of all modern scientific thought and theory. Says Prof. PIERCE:—" This leads us to undertake an account of the idea of force in general. This is the great conception which developed in the early part of the seventeenth century, from the rude idea of a cause, and constantly improved upon since, has shown us how to explain all the changes of motion, which bodies experience, and how to think about all physical phenomena, which has given birth to modern science, and changed the face of the globe; and which, aside from its more special uses, has played a principal part in directing the course of modern thought, and in furthering modern social development." *Page* 295.

The thought of the possibility of Galileo, Newton, and the whole scientific and intelligent world having been in error on this fundamental principle for more than two centuries is one that will not be readily entertained; yet it is apparent that a more momentous question cannot be propounded than — *Is Newton's First Law of Motion true or false ?*

§ 140. Now the proposition stands solely on the dicta of Galileo and Newton, and the acceptance of scientists generally. There is literally no proof of it, and in the nature of things none is possible, for all our knowledge of *force* must come from what we observe concerning its behavior with matter, and when we see a body start to move, and continue to move, we cannot know that that behavior stopped with the initiation of the motion ; we cannot see the force withdrawn or abstracted at that point; we have no evidence that it does not enter into the moving body and go along with it in its motion, that it is not the present and efficient cause of the continuance, as well as of the commencement of the motion. The assertion that matter is equally indifferent to rest and motion, if not a play upon words, is but another expression of the same assumption, and brings no evidential support.

The proposition has therefore none of the elements of fact about it, but, on the other hand, is preeminently theoretical, and subject to all the tests available in discriminating between hypotheses. Indeed, some physicists consider it too inherently weak to stand even as a theory.

Judge Stallo says:—"Physicists are perfectly aware that the sense commonly attached to the word *inertia* in its application to matter is spurious." *Modern Physics, p.* 163.

And the existence of force being admitted in the initiation of motion it is entirely illogical to assume that it then and there disappears, giving place and office to a new attribute or property of matter. Without evidence the probabilities are all *prima facie* the other way.

§ 141. The quotation above from Dr. Whewell gives a clear notion of the opposite theory. It supposes that the motion of a body is not only started by force, but that force enters into it, and carries it forward in its path until the force is overcome, withdrawn, or exhausted, when the motion ceases; that there can be no motion without the active presence of force in the moving body. It presumes propositions the opposite of the assumptions of the Newtonian doctrine; first, that rest only, and not motion, is natural to matter, and, second, that force is a continuer as well as starter of motion. Instead of Inertia being a motion continuer, it makes it simply a principle of passivity, or a susceptibility, in matter of being acted upon by force.

§ 142. It will be seen that the two theories are wide apart, and exclusive of each other, and that, as before remarked, physical science must be one thing or another, as it may be bottomed on the one or the other of these doctrines.

In comparing the two theories, that of Kepler will be found, as it is believed, altogether more consonant with observed facts than the other, indeed, the evidence in its favor will, it is thought, come near, if not quite, to lifting it from the domain of theory into the realm of established facts.

§ 143. The first proof offered is physical and, it would seem should be, conclusive. Suppose a body weighing 20 lbs. to be projected horizontally into the air with a velocity of 100 feet per second, and striking a stationary body of like mass, the result would be, leaving out of view the resistance of gravity and of the atmosphere, that both bodies would move on with one-half the velocity. This proposition is admitted by all physicists. Thus says :

Dr. Stewart, *Conservation of Energy, p.* 89. "An inelastic body of mass 10 and velocity 20, strikes directly another inelastic body of mass 15 and velocity 15, the direction of both motions being the same. The united mass will, after impact, move with the velocity of 17. What, then, has been the influence of the forces developed by collision? The body of greater velocity had before impact a momentum of 10 times 20, equal 200, while its momentum after impact is only 10 times 17, equal 170; it has therefore suffered a loss of 30 units as regards momentum, or we may consider that a momentum of 30 units has been impressed upon it in an opposite direction to its previous motion.

"On the other hand the body of the smaller velocity had before impact a momentum of 15 times 15, equal 225, while after impact it has 15 times 17, equal 255 units, so that its momentum has been increased 30 units in its previous direction.

"The force of impact has therefore generated 30 units of momentum in two opposite directions, so that, taking account of direction, the momentum of the system is the same before and after impact, for before impact we had a momentum of 10 times 20, plus 15 times 15, equal 425, while after it we have the united mass 25 moving with the velocity 17 giving the momentum 425 as before."

§ 144. Now in the first illustration above (§ 143), according to NEWTON'S law, the motion of the first body is *started* by the projectile Force, which then retires from the field and leaves it to pursue its course *without Force*, and under the influence of Inertia alone, so that when it impinges upon the second body, there is no force present, and the motion of the second body is started without Force. It starts without Force, and by the Law continues its course without the presence or action of Force. Now if it should strike a third body that would likewise start and move without the interposition of Force. And so of any imagined series of impacts. Force is necessary to initiate the *first* motion; but no matter how far or how long the motion is continued, or to how many other bodies communicated, Force has no further office, and is no further a factor in the phenomena. And the same is true of Dr. Stewart's illustration. So when a cannon ball is fired into the side of a ship, rending it and throwing the fragments in every direction, the ball is started by the explosive Force of gunpowder but pursues its path without any Force, and scatters the fragments of the ship's walls without the action of any Force. So the waters of the mill stream are started in motion by Force, but continued in motion by Inertia, and the mill wheel, with all its connected machinery, is put into motion and continued in motion without the presence or action of any Force whatever. So the moving currents of the atmosphere are started in motion by Force, but when they strike the fans of the mill, or the sails of the ship, or the waves of the sea, or the blades of the waving grain, or the boughs of the bending forest, these are each and all started and continued in motion without Force, because, according to the hypothesis, there is no Force in the currents of wind which strike them. That is to say, the office and only office of Force in nature is to start motion; yet there is a vast amount of motion in art and nature that is not started by Force. By what is it started? By Inertia? By Motion? We are left to conjecture.

§ 145. But many scientists have observed the fallacy of the proposition that a body moving without Force and by virtue of its Inertia alone can, upon impinging upon another body, set up motion in the latter. They see that if force is only a starter and not a continuer of motion, there is no force—nothing but Inertia in the moving body, so that the motion of the second body must be started, not by Force but by Inertia, and it comes to this, that, while Force is only a starter of motion, Inertia is greater in that that it is both a continuer and starter of motion. And carrying the analysis forward there is no need for but one interference of force in any chain of successive impacts no matter how long, for, after the first body is set in motion, force having done its work retires, and all the other bodies are set in motion successively by the Inertia of the immediately preceding body. So to save this theory of Inertia there must be an invention. That invention is the elimination of Force from the universe, making it a nonentity, a nothing, and supplying its place with motion. They make motion the cause of motion. They say motion once set up continues forever in some form or mode in some body or other.

§ 146. Judge Stallo says: "The mechanical theory postulates *mass* and *motion* as the absolutely real and indestructible elements of all forms of physical existence."— *Modern Physics, p.* 148.

"That force has no independent reality is so plain and obvious that it has been proposed by some thinkers to abolish the term *force* like the term *cause* altogether."—*Ibid, p.* 165.

"The mechanical theory of the universe undertakes to account for all physical phenomena by describing them as variances in the structure or configuration of material systems. It strives to apprehend all phenomenal diversities in the material world as varieties in the grouping of primordial units of mass, to recognize all phenomenal changes as movements of unchangeable elements, and thus to exhibit all apparent qualitative heterogeneity as mere quantitative difference. In the light of this theory the ultimates of scientific analysis are *mass* and *motion*, which are assumed to be essentially disparate. Mass, it is said, exists independently of motion, and is indifferent to it; it is the same whether it be in motion or at rest. Motion may be transferred from one mass to another without destroying the identity of either."—*Ibid p.* 25.

"Accordingly, the mechanical theory of the universe postulates the conservation of both mass and motion; mass may be transformed by an aggregation or segregation of parts; but, amid all these transformations it persistently remains the same. Similarly motion may be distributed among a greater or less number of units of mass; it may be transferred from one unit of mass to any number of units, its velocity being reduced in proportion to the number of units to which the transference takes place; nevertheless the sum of the motions of the several units is always equal to the motion of the single unit. It may be changed in direction and form; rectilinear motion may become curvilinear, translatory motion may be broken up into vibratory motion, molar motion may be converted into molecular agitation; yet during all these changes, it is never increased, diminished, or lost."—*Ibid*, *p*. 26.

§ 147. The inadequacy of this hypothesis has already been shown. It meets none of the requirements of the problem in hand. So far from offering any solution of the phenomena of motion, it resolutely closes the book with the affirmation that no explanation is possible; for, as already seen, continuity of motion, stripped of a persistent cause, is no more than a series of disjointed, disconnected and independent succession of movements. Motion, bereft of all cause for its occurrence, is but a dead and soulless body.

§ 148. And thus does Newton's supposed law lead to contradiction, confusion and absurdity. But, under the view here presented and insisted upon there is no confusion, no inconsistency. In the first illustration above (§ 143) the first body is started and continued in motion by present active force. When it impinges on the other body a part of this force is communicated or imparted to it, causing it to start and continue in motion until this imparted force is communicated to some other body. And because the two bodies are of equal mass the two move on with one half the velocity the first had.

In Dr. Stewart's illustration the motions of both bodies are initiated and continued by force, in the one in the measure of 200, and in the other in the measure of 225. Upon impact the swifter body striking against the slower, imparts to it a portion of its force in measure 30, so that the former now has force in measure only 170, while the force in the latter is increased to 255.

So when the cannon ball is fired into the ship's side, the projectile force of the gunpowder not only starts, but continues the motion of the ball, and upon impact, is part or all communicated to the splinters and fragments of the ship, not only setting up, but carrying on motion in them.

So the motion of the water in the tumbling rivulet is not only started, but continued by force, a part of which is communicated to the mill wheel and connected machinery.

So the moving winds are both started and continued in motion by present acting force, a part of which is imparted to the sails of ships, the blades of grain, and the boughs of trees.

§ 149. And it will be perceived that the Newtonian theory contradicts the doctrine of Conservation, for it assumes that force only starts motion and then disappears. After setting up motion in a body it is no longer traceable, it does not persist as force.

Now, how is the difficulty met at this turn? Why, by making force and motion the same thing. Mr. Spencer says: "Motion, whenever we can directly trace its genesis, we find to pre-exist as some other mode of force."—*First Principles*, p. 195. Prof. Steele says: "What is the nature of force we cannot tell. We think it to be a mode of motion." That is, force and motion are different forms or modes of the same existence.

But several other difficulties are encountered here. In the first place, if it is motion and not inertia which correlates with force and initiates other motion, it is a relegation of inertia from the field, as Judge Stallo admits.

§ 150. In the next place the proposition is not susceptible of being logically construed in thought. It is the assertion that the something which starts a body in its motion from point A to point B is the same thing as the passing of the body through space from the one point to the other. It is the effort to interpret two different orders of existence as being one and the same thing. Whenever the mind attempts to grasp the idea its absurdity at once appears.

§ 151. A greater difficulty presents itself when the attempt is made to make motion the cause of motion. For suppose that body X, having been put in motion at point A by a force, moves through point B to point C, where it impinges on body Y, putting it in motion that carries it to point D, it cannot be said nor thought that the *motion*, that is the passage of Y from C to D is the passage, nor any part of the passage, of X from A to B or B to C. So the flying through space of the splinters from the ship's side cannot be said nor thought as the passage, nor any part of the passage, of the cannon ball from the mouth of the cannon to the side of the ship. It is easy to grasp the idea that some principle which carries X from A to C enters into Y at the latter point and carries it to D; that the something which makes the cannon ball traverse the distance from the mouth of the gun to the ship also makes the splinters pursue their various paths through the air, but the assertion that the successive motions are the same in identity or essence is born of indistinct ideas, or else is but a play upon words.

§ 152. And so of the very closely related idea that the first motion causes or compels the second, that the going of X from A to C compels the going of Y from C to D. When the processes of thought are analyzed it is seen that what the mind grasps, and all it can distinctly grasp, is that upon the occasion of the going of X from A to C, *something* causes or compels Y to go from C to D, and that *something* is not the *motion* of X, though it arises out of that motion. So in reality we come down to the idea—perhaps I should say fact—that that *something* is a *cause* or *force* which being first found active in X, at the point C passes into Y, and compels it to move on to D.

§ 153. And *this* invention to obviate obstructions also controverts Conservation, for it is a continually observable fact that motions do cease. If forces metamorphose into motions, and the motions come to an end, it is obvious that the forces are not conserved. How is this new difficulty to be met? By making motion and rest the same—by having force to metamorphose into motion and motion into rest—by transforming force into rest by two successive metamorphoses. Says Judge Stallo:

"It follows, of course, from the essential relativity of rest and motion, that the old ontological disjunction between them falls, and that in a double sense, rest differs from motion, in the language of Euler, 'as one motion differs from another,' or, as modern mathematicians and physicists express it, that rest is but a special case of motion."—*Modern Physics*, *p*. 203.

That is, the going of X from A to C is the same thing as its remaining at A or at C. The passage of the cannon ball from the cannon to the ship is the same thing as its remaining in the cannon; the revolution of the earth around the sun is the same thing as its remaining fixed at a particular point in its orbit; and thus, by an abstruse metaphysical process, the most opposite things and the most contradictory propositions are found to be identical. No wonder Judge Stallo has a horror of metaphysical reasoning in science, for by such processes any proposition imaginable can be established, and any truth, however fortified, be overthrown.

For at rest a body remains at one point in space, say A, in motion it goes from A to some other point, say B. Now that remaining at A is the same thing, or equivalent to passing from A to B, is a proposition which can only be true in some metaphysical sense so absurdly foreign to common modes of thought and all laws of logical judgment, that it is not needful to follow Judge Stallo through the subtle paths leading to this obscure conclusion.

§ 154. Another argument is founded on the laws of thought. The mind thinks something *in* the moving body causing it to move, not something disparate and far removed, it may be, in distance and time. Now things are not necessarily as they are thought, what is back of thought may be unknown and unknowable, but they must be thought *according to the laws of thought*, and any argument founded on contrary views is worthless.

§ 155. And this remark is relevant to the materialistic notion of cause and effect, which is that it is satisfied with the facts of sequence and consequence, that it is only another aspect of the notion of a succession of events. But it is not so that the mind grasps it, and, therefore, not true to it. It is true that as the notion of cause is that of an actor acting, of *something* doing something, it includes the notion of a succession, of a changing from one *locus*, or *status*, or attitude, or state, to another; but it includes also the further and higher notion of the *something* which does, causes or produces; a *something* which educes and compels the transition, and without which no thought-change would be possible. Now whether there is such a *something* in absolute being is not under discussion; but instead, the fact that the mind does and must think it and that all logical argument must predicate it. If any man is of the opinion that the necessary results of his own mental laws should be discredited, all that can be said of him is that he puts himself outside of the pale of logical discussion. But in this argument, whatever the mind, by virtue of its constitution is compelled to think, is taken as being absolutely true, however it may in fact appear and be to Supreme Wisdom. The very essence of existence cannot be compassed, subtended, or grasped by finite mind, and, therefore, we must either accept the deliverances of thought as forced upon us by the laws of mind, or submit to a self-stultification almost equivalent to intellectual suicide. He who stumbles at the boundaries of thought by which his mental finitude hedges him in, rejecting the finite which he may know because of the infinite which he cannot know, places himself on a plane too elevated for logical argument.

§ 156. A critical analysis, therefore, leads to the conclusion that the two theories are so entirely exclusive of each other that neither of them can be partially true ; but that, on the contrary, one or the other must be wholly true and occupy all the ground. If force is not necessarily present as a continuer of all motion ; neither is it necessarily so as a starter of motion ; for a vast amount of motion is commenced without it, and those physicists proceed on logical principles who banish it entirely from the realms of scientific thought. And this leaves us only motion as the cause of motion ; as Judge Stallo logically puts it, " Mass and motion " are the only realities existent. And as the mere translation of one body over one distance or line of space cannot be conceived as the translation of another and different body over another and different line of space, nor as being the cause of the latter, it follows that the further theory of materialistic physicists that there is no such thing as *cause* at all, but that, on the contrary, what has been heretofore denominated *cause and effect* are but necessary successions of events or actions growing out of the inherent qualities of things and the inevitable laws of nature, becomes a logical necessity. So that the logical outcome of " Newton's First Law," as generally understood, is, that the universe is a vast piece of necessary mechanism, a huge automaton moving on without force, without cause, without reason, under the unswerving rule of inexorable law. Freedom is not, liberty is not, will is not, design is not, Deity is not. What is to-day is simply a necessary result of what was yesterday, and that of what was the day before, and so on, back through the eternities. Knowledge is but the chronology of events, reason but the presaging that one event will follow another to-day because it did so yesterday, science but the mapping of the inexorable course of the succession of natural phenomena.

On the other hand, if Force is admitted as a factor in nature at all, it must be admitted all the way. When once given a foothold at all, it cannot be logically excluded. If it is found necessary in the smallest of nature's operations, it will be equally necessary in the largest, and in all. It must be rigidly exorcized and ostracized as a useless and unmeaning term invented to cover an imaginary principle, or else given scope as one of the grand and necessary realities of existence upon which depends all the phenomena of nature. And in admitting it, we also admit and invite to critical discussion, the possibilities of design, will, freedom, creation, and Deity. So it will be seen that the two theories are as wide apart, divergent and contradictory as truth and error, as yes and no!

§ 157. And not only does the "First Law" necessitate the destruction of the notion of force but that of energy as well, for the latter term must mean either some species or mode of force, or some principle analogous to what we have heretofore understood as the notion of force; or else it must mean the continuity or correlations of motion,—and the one of these ideas is, as we have seen, exclusive of the other; there is and can be no middle ground between for energy to stand upon, it is and must be an analogue of the one principle or the other. And here again we see that Judge Stallo is consistent; on the Newtonian theory, motion is all there is to be conserved; with the necessary corollary that motion and rest are identical; and there might be added, the further corollary, that there is no distinction anywhere between opposites, and all reasoning is but a childish play with terms and phrases.

§ 158. It follows, therefore, that if the "First Law" as interpreted is to stand as the basis of physical science, all the high-flown rhetoric relative to the

"Persistence of Force," "Correlation of Forces," and "Conservation of Energy," becomes but as chaff before the wind. The one part or the other of modern physics must be taken down and rebuilded. Only the ultra necessarian, the fatalistic materialist, can continue to stand upon the "First Law." And all those who would save any remnant of the doctrines of "Persistence," "Correlation," and "Conservation," must find their basis and support in the Keplerian theory of Force. In logical consistency they must give up either Newton's First Law, or the whole doctrine of Conservation in all its forms and ramifications. They must choose on the one hand between Galileo and Newton with inexorable, designless, causeless, forceless, necessitated automata, or, on the other, Kepler with living forces, susceptible of designed action and liable to subjection to free volition and to control by Deity.

§ 159. It remains to be seen whether or not the Keplerian philosophy of force can be made to account for the phenomena of physical nature; whether or not its inadequacy shall drive us back to mutely accept with paralysis of intellect the fateful automatism of mechanical nature necessarily superimposed upon Newton's First Law!

CHAPTER IX.

GRAVITATION.

PRINCIPLES PROPOUNDED BY WM. B. TAYLOR—ANALYSIS OF—ACTIO IN DISTANS—STALLO—MAYER—STEWART AND TAIT—NEWTON—FARADAY — CROLL — PROCTOR — BOAT PULLED BY ROPES—COMPOSITIONS OF TENDENCIES—CONSTANT CHANGE OF—METEOR—A PROPERTY OF MATTER—MERRIMAN—MAYER — A FORCE — BEHAVIOR IN UNSUPPORTED BODIES — IN SUPPORTED BODIES —GUILLEMIN—GROWING UP IN BODIES — TWO CHARACTERS OF FORCE—SINGLE PROPULSION—GROWING UP FORCES—DOING WORK—CANNON BALL ILLUSTRATION—DISSIPATION OF FORCE—GRAVITY RECEIVED AND DISSIPATED.

§ 160. The following are the fundamental principles of Gravitation as laid down in an exceedingly able paper by Mr. Wm. B. Taylor of Washington, D. C.

"It is well to bear in mind that every hypothesis directed to the explication of gravity, is required *in limine* to give a satisfactory account of the following six characteristics of this mysterious influence:—

"1st. Its *direction* is towards the acting mass, or rectilinear—indefinitely. This rectilinear traction is incapable of deflection by any intermediary force. It suffers neither disturbance nor interference from any multiplication of similar lines of action, and admits neither of reflection, refraction nor of composition.

"2nd. Its *quantity* is exactly proportional to the acting mass—indefinitely. Corollary ; hence,

"2nd b. Its integrity of action is complete with every accumulation of additional demand; that is to say, no multiplication of duty in the slightest degree impairs its previous tensions.

"3rd. Its intensity is diminished by recession, in proportion to the square of the distance at which it acts—indefinitely; in a manner somewhat analogous to—but (as modified by the second condition) radically different from—the action of light.

"4th. Its *time of action* is instantaneous throughout all ascertained distances, and therefore presumably —indefinitely. Corollary: hence,

"4th b. Its *rate of action* (if the expression may be tolerated) is precisely the same on bodies at all velocities—indefinitely. It no more lags on a comet approaching the sun at the inconceivable speed of two hundred miles in one second than on a body at the lowest rate of motion, or than on the same comet receding from the sun at the same velocity.

"5th. Its *quality* is invariable under all circumstances—indefinitely. It is entirely unaffected by the interposition of any material screens, whatever its character or extent; or, in other words, it can neither be checked by any insulator nor retarded by any obstruction.

"6th. Its *energy* is unchangeable in time, certainly for the past two thousand years; presumably —indefinitely. Corollary: hence,

"6th b. Its activity is incessant and inexhaustible—indefinitely; the ceaseless fall of planets from their tangential impulses involving no dynamic expenditure in the sun or in other known matter." *Smithsonian Report* 1876; page 211.

§ 161. As a basis for the discussion of gravity the following exhaustive analysis of Mr. Taylor's "six characteristics" is submitted:—

1 The direction of gravity is rectilinear,
2 Towards a mass,

3 Which mass is *acting*.
4 It is a traction,
5 Incapable of deflection by any intermediary force.
6 The multiplication of similar lines of forces does not disturb it.
7 It does not admit of reflection,
8 Nor refraction,
9 Nor composition.
10 Its quantity is proportional to the "acting mass."
11 No multiplication of duty impairs its previous tensions.
12 Its "*intensity*" diminishes by recession proportionally to the squares of the distances.
13 Its "*time of action*" is instantaneous at all distances.
14 Its "*rate of action*" is the same on bodies at all velocities.
15 Its "*quality*" is invariable under all circumstances.
16 It is unaffected by the interposition of any material screen.
17 It cannot be checked by any insulator,
18 Nor retarded by any obstruction.
19 It has "*energy*,"
20 Which is unchangeable in time.
21 Its "*activity*" is incessant,
22 And inexhaustible.
23 The ceaseless fall of the planets from their tangential impulses involves no dynamic expenditure by the sun on other known matter.

ACTIO IN DISTANS.

§ 162. It will be shown hereafter that Mr. Taylor's list of "characteristics" is incomplete while some of his assignments are erroneous. In the first place, however, attention is called to his position on the *locality* of gravity. As will be seen, he places it in the body towards which the motion is set up; that is, he makes it a traction or pulling force. To do this he accepts without reserve the doctrine of *actio in distans.* He says:— "It *may* be a fact of natural law that *everythiny* 'acts where it is not,' including even an ethereal vibration; and certainly there is no difficulty in believing it." *Ibid.*, 262.

Again:— "And thus whether we contemplate the infinitely small or infinitely grand, in every case comes back upon us the wide inductions, that the action of the matter in atom, in molecule, or in mass, is *ever* at a distance! Of actual *contact* there is probably no instance afforded in nature, except in the intimate substance of the ultimate atom. * * *

"The assumption therefore of a material band or bar between bodies, to transmit energy from one to another, whether by a pull or by a push, is still very far from establishing an action by *contact*, or from sustaining the fond hypothesis that an atom 'acts where it is!' Admitting a connecting rod for drawing a railway train of dynamic, as Professor Maxwell has remarked, 'the action of the rod is explained by the existence of internal forces in its substance; and the internal forces are explained by means of forces assumed to act between the particles of which the rod is composed, that is, between bodies at distances, which, though small, must be finite. The observed action at a considerable distance is therefore explained by means of a great number of forces acting between bodies at very small distances, for which we are as little able to account as for the action at any distance, however great."

"To the wondering inquiry what possible explanation can be given of such a theory or hypothesis of attraction, the obvious answer is, there is neither 'theory' nor 'hypothesis' in the case. The observed fact that one body does actually induce approach, in another body at a distance from it, if accepted as an ultimate one, is, of course, thereby excluded from all idea of explanation.' And as this observed fact, by the multiplicity of instances in which no intermediate agent has yet been detected, or rendered rationally plausible, is generalized into an 'induction,' the burden of proof lies entirely on the shoulders of those who with keener vision through nature's veil, are ready to proffer hypotheses without 'assumptions,' and endless motions without the aid of 'occult qualities."—*Ibid*, 281.

And Judge Stallo says:— "The very presence of a body in space and time, as well as its motion, implies interaction with other bodies, and therefore *actio in distans*."—*Modern Physics, p.* 163. A piece of highly metaphysical proof, indeed!

§ 163. But Mayer says:— "Gravity cannot act except by the interposition of ponderable matter;" and E. Du Bois-Reymond says:— "Forces acting through void space are in themselves inconceivable, nay, absurd, and become familiar concepts among physicists since Newton's time from a misapprehension of his doctrine and against his express warning." *Ibid*, 58.

Profs. Stewart and Tait say: "Of course the assumption of action at a distance may be made to account for anything; but it is impossible (as Newton long ago pointed out in his celebrated letter to Bentley) for any one 'who has in philosophical matters a competent faculty of thinking' for a moment to admit the possibility of such action." *Unseen Universe, p.* 100.

§ 164. Newton's language is: "That gravity should be innate, inherent and essential to matter, so that one body may act upon another at a distance, through a vacuum, without the mediation of anything else, by and through which their action and force may be conveyed from one to another, is to me so great an absurdity, that I believe no man who has in philosophical matters a competent faculty of thinking can ever fall into it."—*Works, vol.* 4, *p.* 438.

§ 165. Faraday says: "I believe I represent the received idea of the gravitating force aright in saying that it is a simple attractive force exerted between any two of the particles or masses of matter at every sensible distance, but with a strength varying inversely as the square of the distance. The usual idea of the force implies direct action at a distance; and such a view appears to present little difficulty except to Newton, and a few, including myself, who in that respect may be of like mind with him. This idea of gravity appears to me to ignore entirely the principal of the conservation of force; and by the terms of its definition, if taken in an absolute sense, 'varying inversely as the square of the distance' to be in direct opposition to it."—*Phil. Mag., vol.* 13, *p.* 228.

§ 166. Says James Croll: "It was demonstrated by Newton, and has been proved by general observation and experience, that bodies tend toward each other with a force varying inversely as the square of the distance, and directly as the mass of the bodies. But, it never was demonstrated or proved by any one that the bodies *attract* each other. The thing which has been demonstrated is that B tends towards A; but the theory does not rest here; it goes on to account for this tendency by referring it to a hypothetical cause, viz., to the 'attraction' of A. This however, is a mere hypothesis, and no way essential to the theory. All that the theory requires is that it be demonstrated that B tends to move towards A. It is not necessary that we should go beyond this, and attempt to explain the cause of this tendency." —*Phil Mag., vol.* 34. *p.* 450.

"The theory is also opposed to the principle of the conservation of force, as has been shown, I think, clearly, by Faraday. When a stone, for example, is thrown upward from the earth, it not only loses all its motion, but loses its attraction in proportion to the square of its distance from the center of the earth. What becomes of the motion imparted to the stone? It is not transformed into attraction, for the attraction diminishes as well as the motion. When the stone again falls to the earth it gains both motion and attraction. In the former case, the attraction is said to consume the motion, and instead of becoming stronger becomes weaker in consequence; and in the latter case it imparts the same motion, and yet, after imparting the motion it is actually found not only not to have lost but to have gained force thereby. Faraday justly asks what becomes of the force or motion imparted to the stone? It is not converted into attraction, for the attraction becomes less instead of greater in consequence. And in the case of the falling stone where does the motion come from? If the motion arises from the attraction of the earth, then there must be a certain amount of this attractive force converted into motion; and, if so, the attraction force should be so far reduced; but instead of this it is actually increased. There is therefore no account given of what becomes of the motion externally imparted to the stone when thrown upwards, or whence the increase both of attraction and motion is derived as it descends. If the attraction theory be correct, then there is a destruction of force in the one case and a creation of force in the other; and, if so, then the conservation of force is violated."—*Ibid*, 451.

§ 167. Says Richard A. Proctor: "Now at the very outset, what a mighty mystery is thus unveiled! I know nothing indeed more mysterious (more hopelessly mysterious, one might say, if one could limit the possibilities of future research) than the mystery of gravity. It has been said, and truly said, that

> 'Nature and Nature's laws lay hid in night,
> God said, "Let Newton be," and all was light.'

All was indeed light where before men had been groping in darkness. But outside the region where they had thus been searching far vaster regions of darkness were revealed. A veil was lifted, and one of nature's mysteries was interpreted, but a more impenetrable veil was seen beyond, which as yet no man has even hoped to lift. What greater mystery can there be than this, that matter acts where it is not? The sun on the earth and all his planets, the earth on the moon, Jupiter and Saturn on their world systems, planet on planet, star on star,—nay, every particle of matter on every other throughout infinity of space. And, not only so, but time apparently annihilated as well as distance."

§ 168. Prof. Young says: "We must not imagine the word 'attract' to mean too much. It merely states the fact that there is a *tendency* for the bodies to move toward each other, without including or implying any explanation of the fact. So far, no explanation has appeared, which is less difficult to comprehend than the fact itself. Whether bodies are *drawn* together by some outside action, or *pushed* together, or whether they themselves can act across space with mathematical intelligence—in what way it is that 'attraction' comes about is still unknown—apparently as inscrutable as the very nature and constitution of an atom of matter itself; *it is simply a fundamental fact.*"—*Text Book of Gen. Astronomy, p.* 109.

Prof. Lovering says: "The great question of the eighteenth and nineteenth centuries: Is action at a distance a reality, or is gravitation to be explained, as we now believe magnetic and electric forces must be, by action of intervening matter?"—*Pop. Sci. M., Jan'y*, 1875, *p.* 316.

§ 169. A great many other physicists find difficulty in accepting the notion of *actio in distans;* but generally they do not attempt to shift the location of the force, but, on the contrary, to find some material medium, some physical lines by or through which the attracting body can draw the attracted body towards it; this is called the Kinetic Theory of Gravity. But Mr. Taylor, in the paper quoted from, has most effectually disposed of all such theories as have heretofore been urged in support of such drawing medium. Yet he, with the others, leaves the hypothesis of an opposite locality of the gravitative force untouched. Then why may it not be that Gravity is a driving force rather than a drawing force? that it is located in the gravitating body rather than in the body towards which it gravitates?

In considering this theory, it may be observed in the first instance that it makes no difference in the intensity of the force, nor yet in the distance rate or increase or diminution of the force, whether it be located at the one end of the line as a pulling force, or at the other end as a pushing force. A boat will approach the shore with the same speed, if a man standing on the bow pulls at a rope fastened to the shore, as if he stands on the shore and pulls at a rope fastened to the bow. The only difference is that in the first instance the origin of the force—the *energy*, is on and a part of the moving body, and in the other, the origin of the force is upon and a part of the body towards which the motion is set up; but *the force itself which causes the motion is transferred from the shore to the boat, from the body towards which the motion is carried forward to the moving body, through the medium of the rope. So in either case the force acts where it is and not where it is not*, though in the latter case it is where it is by reason of its transference through the material rope.

§ 170. And so with gravity. It acts upon and is present in the moving body, and the question at issue is whether it originates there, or originates in the body towards which motion takes place, and is thence transferred to the moving body. So the real question in *actio in distans* is, whether force can be transferred from one body to another at a distance without some connecting medium? Newton, Faraday, Croll, and others, say it cannot, and yet they have utterly failed to find the connecting medium. Taylor, Stallo, Maxwell, and others, say it can and point to our illustration of the rope as proving it. But the particles of the rope, though supposed not to be in actual contact, are nevertheless held together, one to one, throughout its extent, by molecular forces capable of exercising great resistance to traction, and so, when the pull is put on at the shore end, it is resisted by these molecular forces successively through its whole length, and by virtue of such resistance, the force is transmitted through the whole rope to its attachment on the boat. But if at any point the molecular holding of the particles should be unequal to the traction of the man's pull, the rope would snap at that point, and the force would fail of transmission to the boat.

So in this illustration, the force is transmitted to a distance over, as is supposed, spaces unoccupied by matter; but if these spaces are not filled in by forces clasping on either hand the particles of matter adjoining, it must yet be that in the particles themselves are forces which tenaciously hold them in place relative to the neighboring particles, and whichever it be, these forces resist the tearing asunder of the particles, and, by reason thereof, afford a pathway for the transference of force from the man to the boat. Now, therefore, before Taylor, Maxwell, and others, can legitimately use this illustration in argument for *actio in distans*, it devolves upon them to show some connecting medium in which particles or atoms are held together by forces resistant to the attractive pull. And this is exactly what Mr. Taylor shows has not been done.

§ 171. But Mr. Taylor exhibits the strength of his side of the contention, in a single phrase: "The observed fact that one body does actually *induce* approach in another body at a distance." Whether we consider that gravity pulls or pushes, the one body moves towards the other *because* that other is where it is, and, if it were not there, the moving body would not move in that direction; and therein the motion of the moving body may be said to be *induced* by the other body, no matter in which the original force resides. And to get a good comparison of the merits of these two theories on this point, let us go back to our boat again, and suppose two men on the shore line one hundred yards apart, pulling with equal strength by ropes attached to the boat. There being no current in the water, it is easy to see why the boat will touch the shore midway between the two men on the principle of the composition of forces; that is, the pulling energies of the two men are conveyed through the ropes to the boat, where a composition of the direction and strength of the pulls takes place, according to the law of the parallelogram of forces, giving a direction between the two, and a higher velocity than either. And it will be precisely the same, if we suppose the two men pulling from the deck of the boat, and the ropes fastened where the men stood on the shore.

§ 172. Now let us transfer our illustration to the heavens. Take a meteor, which, in its flight through space, chances to visit our system for instance, and at any moment of time, it has a tendency to approach each body in the solar system with intensities varying, directly as their masses, and inversely as the squares of their distances, and it will have a motion whose direction and velocity will be determined by the composition of these various tendencies, or *inducements*, to use Mr. Taylor's expression.

Now these tendencies, and consequent compositions of motion, are readily understood, if we can first know or assume, that each of the bodies of the system exercises a pull on the meteor proportioned severally as above, directly as the masses, and inversely as the squares of the distances, and, in addition, *a means or medium of transferring these various pulls to the meteor*, but, if the original force is resident upon, or in the meteor itself, it is difficult to conceive how it can, at one and the same time, have these various tendencies to motion, that is, how these various *inducements* are communicated or brought to bear upon it, and evidently, whichever view is adopted, we are close down, as Mr. Taylor says, to the ultimate and unexplainable:—But it should be remembered that the doctrine of *actio in distans* is necessarily, predicated upon a hypothesis not only wholly assumed, but in direct contradiction to all known facts and experience; on the contrary, the opposite doctrine stands upon admitted, but wholly unexplained, facts.

Composition of Tendencies.

§ 173. And, right here, it may be observed too, that, whichever view may be taken of these opposite theories, Mr. Taylor is evidently in error about there being "no compositions" in gravity. The fact is, that we have no experience with it, except as a composition of tendencies, or a resulting motion from such tendencies. And it is not alone towards the several hundred astronomical bodies of our solar system, that our meteor has tendencies to motion, but towards every material body, so far as the laws of gravitation may extend, in the whole universe; and its actual motion in direction and speed, at any moment, is the composited result of all this almost infinite number of tendencies.

§ 174. Now as the meteor itself is in rapid motion, it follows, of course, that its distance and direction from every other body in the universe changes momentarily, and therefore, the direction and actual, as well as relative strength of every one of the tendencies changes as constantly, with the result of a continuous change of the composited tendencies, and of the direction and speed of the motion arising therefrom.

Not only so, but, as all the bodies of our system, as well as many and perhaps all outside of it, are in motion, and, therefore, continually changing their positions relative to each other, and to our meteor; it follows that on that account, as well as by reason of the motion of the meteor itself already referred to, their directions and distances relative to it suffer continual change ; therefore, at each moment its tendency to motion towards each body, as regards both direction and intensity, is modified by the motions of both the meteor itself and the body, and the resulting motion at any moment is made up of composited tendencies dependent upon distances and directions, in each instance modified by the motions of the meteor, relative to each one of the bodies, and of each one of the bodies relative to the meteor.

§ 175. And now what is true of the meteor relative to all the other bodies within the range of gravitative influence, is true of each particle, molecule, and atom of the meteor, relative to every other particle, molecule, and atom in the same range. Each material atom has a tendency to move towards every other atom, with velocity proportional directly to mass or weight and inversely as the squares of distances ; and the actual motion at any moment, as regards both rate and direction, is the composited result of all these tendencies. And there is this same continuous change of relative position towards every other atom in existence, dependent on its own motion, as well as upon that of each of the other atoms in the universe with the consequent recompositing of tendencies, and resulting motions, already discussed regarding the meteor itself.

§ 176. And, however short the time, a moving body or atom has some motion, even down to the infinitely small, both in time and space ; but every change of position, however small, even down to the infinitely small, causes a change of relative direction and distance from every other body or atom, so that these tendencies to motion as regards every other body or atom, are modified in every portion of time however small, even down to the infinitely small; and as a consequence, these tendencies are continually, recomposited into new intensities and directions, with consequent new directions and velocities of motion in every period of time, however small, even down to the infinitely small; so that in trying to grasp the notion of gravity, we have to hug the edges of the infinite on every side; and the unanswered question comes back to us—is the origin of this gravitative force in the moving atom, or in the atom towards which it moves? Is it a push or a pull? Is the *inducement* to motion the effect of a cause exerted in the other atom, or is it a tendency which springs up in the moving atom itself? As we have seen (172) the last position presents an unexplained fact, the first presents an unexplained theory contradictory to fact. Philosophically, the unexplained fact is preferable to the unexplained theory.

What is Gravity?

§ 177. Prof. Merriman calls it a property of matter. "The attractive force, gravity, chemical affinity, and cohesion, whether these forces are many or one, are inherent properties of matter."—*Pop. Sci. Monthly*, *April*, 1877, *p.* 705.

And Prof. Mayer says:—"Gravity being regarded as the cause of the falling of bodies a gravitating force is spoken of, and so the notions of *property* and *force* are confounded with each other, precisely that which is the essential attribute of every force—the *union* of indestructibility with convertibility—is wanting in property; but between a property and a force, between gravity and motion, it is therefore impossible to establish the equation required for a rightly received causal relation. If gravity be called a force a cause is supposed which produces effects without itself diminishing, and incorrect conceptions of the causal connections of things are thereby fostered. In order that a body may fall it is no less necessary that it should be lifted up, than that it should be heavy or possess gravity; the fall of bodies ought not therefore to be ascribed to their gravity alone." *Forces of Inorganic Nature, p.* 253.

This is a clear acknowledgment by Dr. Mayer that if gravity is to be considered as force instead of as a property of matter, Conservation cannot be true, and therefore he relegates it to the shades, as Stewart and Tait do by force. His reasoning is short, and to himself conclusive no doubt: "Conservation is true: All forces persist and correlate; but gravity does not persist and correlate; therefore gravity is not a force although it behaves as forces do." He assumes that Conservation is infallibly true, and then pares gravity down to accommodate it.

§ 178. To the most casual thought the inquiry will appear vastly important, whether gravity be an independent entity, or a quality, property, or attribute of matter? The only argument advanced in favor of the latter proposition is Prof. Mayer's argument, that the converse is inconsistent with and destructive of the doctrine of Conservation. The inference of Conservation having been drawn from a few facts, all other facts in nature must be warped to fit the theory. This is an unphilosophical and illogical method of argumentation, and brimful of error. Let a few of the facts which seem to militate against the theory be briefly stated. Gravity increases or decreases proportionally with the increase or decrease of mass in the body towards which it tends to set up motion. It is easy enough to understand why a quality inherent in body A should increase or diminish as body A grows or wastes away, but no reason is seen why such quality should suffer increase or diminution proportionally as body B grows or lessens.

Again, gravity varies inversely as the squares of distances, and no reason presents itself why an attribute or quality should vary in intensity in such, or any other proportion to the variance in the spatial distance of some other body. And, again, gravity is something which accumulates in unsupported bodies but is transmitted in supported bodies. It is not known that any attribute or property behaves in this way. Once more, gravity is a *motion maker*, and we are not in the habit of assigning this office to qualities.

Indeed, it seems much more consonant to true philosophical methods, to give gravitation a place on the list of the great forces of nature, letting the after consequences take care of themselves, than to dwarf it down to a place amongst the qualities of matter lest it should form a stumbling-block to the petted theory of Conservation. If gravity is not to be considered a force, no reason is seen why any thing else should be so called. If gravity is only a property or quality it is not perceived why any other *motion maker* should not be put in the same category. If common words are to bear common sense meanings and indicate common sense distinctions we cannot afford to define gravity as a property.

§ 179. And indeed, gravity is more usually called and considered a force by scientists, and particularly by the astronomers. But a good way to ascertain what it is is to see how it behaves—what it does. The following facts concerning it may be noted.

By reason of it unsupported bodies fall to the ground. We are in the habit of calling those things which determine action, generally, *causes* of the resulting actions, and, specifically, *forces*. Gravity, then, in determining the fall of bodies behaves as other things do which are called *causes* and *forces*, and we are, therefore, authorized to so call it.

A falling body at the end of one second will have a certain speed, at the end of two seconds twice, at the end of three seconds three times that speed, and so on. This is different from the ordinarily observed behavior of most other forces. When a rifle is fired the ball commences motion with a certain velocity which is never increased, but on the contrary, diminished by the resistance of the air. The same is true of an arrow shot from a bow, a marble rolled on a smooth floor, or a ball on ice. Now let us closely analyze these cases. The bullet, arrow, marble and ball, each starts with a certain impulse or magnitude of force which is not increased, else the speed would be increased. But the falling stone starts with no appreciable speed, at the end of one second it has speed at the rate of 32 feet per second, at the end of two seconds 64 feet, and at the end of three seconds 96 feet per second, and so on. At the beginning it was almost destitute of motion, and therefore of that which determines or causes motion, to wit, force; but, unlike the bullet or arrow, when it has been moving one second it is found that its motion has very greatly increased, and as long as the fall continues its speed continues to increase. But there can be but one sensible reason for this, that principle which determines motion in it has increased. And this increase of speed is found to be equable and uniform, 32 feet in each and every second of the fall. Therefore, the determining cause of its motion must have increased proportionally and uniformly. That is, when the stone rolls from the cliff it is almost without motion, and, therefore, almost without anything in it to set up motion; but the longer it is unsupported the more motion it gets, and, as we have seen, that must be because it gets the more of that which causes motion—force—in this instance, gravity. So we see gravity grows up, so to speak, uniformly in bodies unsupported, and causes them to fall with uniformly accelerated velocities. *This is the way it behaves.* These are facts and our interpretation ought to be in accordance with them. It is not good to invent theories and then bend and disguise facts to fit them. But, if Dr. Mayer is correct, that which grows up in the body during its fall is a *property* or *quality* of the body. It commences the fall with almost none of this property and ends with a great deal of it. And, strange to relate, when the fall ceases this property is all transferred! So it is only an accidental property or attribute of the body. If it had never fallen it would never have possessed the attribute. This sounds like child's prattle.

§ 180. But why does not gravity *grow up* in the supported body? Why does it not determine motion there? The latter question is easily answered; it does not determine motion there because the supports will not let it; they resist. But remove the supports in any way, and then how does it behave? Slip the supports from under it, and what does it do? Why, it falls precisely as it did when rolled over the precipice. But how does it behave while lying on the cliff? First, move its locality, and see how it will behave. Put it in the pan of the grocer's scale, and what does it do? Why, it balances the sugar in the other pan for any length of time we may leave it there. Fasten it to the cord attached to clock work, and what does it do? It descends very slowly until the cord is unwound to its full length, all the time determining motion in the wheels and hands of the clock. Lay it on the surface of the water, and how does it behave? It sinks to the bottom. Lay it on a pile of egg-shells, and how does it act? It crashes through. Hold it in your hand, and what then? After a time your arm becomes *tired*, and finally the muscular strength of your limb is all exhausted. Now, what is to be gathered from all this behavior? Why, evidently, that there all the time tends to grow up in the stone that which determines motion, and which *causes* motion when the resistance of the supports is unequal to the tension, but which passes downward through the supports in the form of pressure where they do not give way.

§ 181. Amédée Guillemin says: "Nor is it only moving phenomena which familiarize us with the action of the weight; it exercises itself also incessantly on bodies which appear to us to be at rest, and which in reality are only in equilibrium. The stone which has touched the ground, the fall of which our eyes have followed, continues thenceforth to weigh on the surface which upholds it, and this pressure, which is rendered evident by the constant tension of a spring, is rendered sensitive to our organs by the effort which the hand is obliged to use to support the stone.

"A book placed on a table remains at rest, but presses on its support which itself rests on the ground. A mass of metal suspended at the lower end of the thread or flexible cord stretches the thread or cord; this tension, which continues as long as the suspending thread is not cut, proves the continuous action of the force on the suspended body.

"We must therefore clearly understand that rest is not synonymous with inaction, and we may be assured that, on the earth, no material particle, whether solid, liquid, or gaseous, is ever free for one moment from the action of this force."—*Forces of Nature, p.* 4.

§ 182. It follows, therefore, that there is a like tendency in both supported and unsupported bodies for gravity to grow up in them; in the former it is conducted or conveyed away in the form of pressure through the supports without determining motion; but in the latter it accumulates so long as unsupported, uniformly determining uniformly increased motion. The uniform motion of the clock-work also shows that the action in pressure is uniform.

§ 183. A corollary to all this is that the only difference between the gravity in a falling body and in one at rest lies in the accidents of support or no support, with the consequent results of the conduction or accumulation of the gravitative force.

§ 184. We have, then, so far, two classes of kinetic force—one a single propulsion of a definite magnitude producing a definite velocity, not increasing or growing to any greater magnitude, but, on the other hand, subject to continual diminution, by reason of resistance; and a continually increasing force, equal increments in equal times. Of course, if the latter were analogous to the former, there could be no increase of velocity in a falling body, and after the first impulsion of pressure was conducted downward, as may be witnessed in the blow of a hammer on an anvil, bodies at rest would be without weight.

Doing Work.

§ 184. The force of gravity in falling water may be made, by proper machinery, to produce motion of any kind, in any direction, and to do any character of work. So may the gravitative pressure in a head of water, or in a suspended weight, or on the end of a balanced lever. From all of which it appears that gravitative force, whether in a falling body, or as pressure, may be drawn off, used and utilized as any other force. So that, except in the manner of growing up in bodies, it behaves just as any other kinetic force does.

§ 185. We have already seen that in its very inception, and primal tendencies to motion, gravitative force is composited in direction and intensity according to the law of the parallelogram. It is also continually composited with other forces in falling bodies, as it is in pressure. The latter is instanced in the flow of rivers and glaciers, and in various other forms of pressure.

§ 186. Another corollary to all this is, that, be the original source of gravity where it may, in the falling body or in the earth towards which it falls, the force is either primarily or by transference, *present in the falling body*, for it may be drawn off from it, as we have seen, and utilized in endless ways.

§ 187. If any rectilinear propulsive force of a single impulsion be made to act against any constant resistance, as that of a spring, or of friction, the initial velocity of the body in which the motion is set up will be uniformly retarded until the motion is all overcome by the resistance. And when a body is projected upward by any force, it behaves in the same manner. Suppose a cannon-ball shot toward the zenith by the explosion of gunpowder. At the moment of starting upward its contained gravitative force may be considered infinitely small in quantity, because until the commencement of the ascent it was all the time being passed downward through the supports beneath. While ascending, as well as at the very moment of reaching the summit of the ascent, the contained gravity may, at every point, be considered infinitely small, because it is continually balanced and neutralized by the projectile force. But upon reaching the summit of the rise, which is the point at which all the propulsive force becomes exhausted, the ball turns in air and commences to fall with uniformly accelerated speed, because the constantly and uniformly growing-up gravitative force in it, being neither transmitted downward through supports, nor exhausted by resistance from other forces, accumulates uniformly until it reaches the ground, when it is all imparted in the impact as pressure, heat, vibration, or in some other manner. But if, on reaching the highest point of the ascent, the ball be caught on a cliff, then, instead of gravitative force accumulating in it, it is in the same quantity per unit of time, transmitted downward as pressure. Now, note that the ball starts up with a certain initial velocity, all the time of the ascent it is acted upon by gravity, and the result is that at the acme of the ascent the projectile force is all gone, and it has no accumulated gravitative force. The two equal forces are both gone without leaving track or trace behind. If there had been no gravitative resistance, the projectile force would have carried the body on through all time, perhaps. If there had been no projectile force, gravitative force would have been all the time pressing downward as weight; but the coetaneous opposite actions of the two have wiped both out; and the ball, so far as any contained force or motion is concerned, is as if it had never been acted upon by either force.

§ 188. Corollary: Two equal portions of opposite forces are here exhausted, dissipated, or lost from our realizations, never more to appear, so far as we know, as factors in the material universe. We can affirm neither that they are, nor that they are not absolutely destroyed, for we do not and cannot know; they are lost to our recognition—we can say no more.

§ 189. Corollary: A like dissipation of forces occurs whenever any other force is brought into resistance to unsupported gravitative force.

§ 190. Corollary: A like going out of recognition occurs whenever two unsupported forces oppose each other.

§ 191. Corollary: All this is in accordance with and governed by the law of the parallelogram of forces, and under that law there is always a dissipation of opposing forces.

§ 192. Corollary: By these facts the doctrine of Persistence is invalidated and confuted.

§ 193. Corollary: Gravity is a something which does as forces do, behaves as forces behave; but also a something which is continually and uniformly growing up or coming into recognition, acting and passing out of observation like a continuous stream whose beginning is first noted in the gravitating matter, and which, when not met, obstructed and dissipated by opposing forces, flows downward towards earth's center so far as we are able to trace it. In falling bodies, there is in every successive moment more and more of this *something* present; in ascending, it is lost as soon as found, like snow which melts as fast as it strikes the warm ground; in supported bodies what was in them a moment ago is gone now, what is in them now will be gone a moment hence. So that gravity is a continually received something in all matter, so far as we know; call it what you please, names matter little if we are able to grasp the thought, the *fact*. And here are the facts—they may be explained or disguised, but cannot be subverted by theories. They do not, and, when looked squarely in the face, cannot be made to support the doctrine of Conservation in either direction, for they show that the grandest motion-maker, worker, and energy-producer amongst all of Nature's forces, is continually coming anew into observation, quantitative measurement, and calculation, and as continually passing forever out of our reach and ken.

How Gravity Acts.

§ 194. The operations of gravity have already been likened to a pulling upon ropes, and it has been seen that the principle is the same, whether we imagine each atom connected with every other by pulling cords, or each body connected in such manner to every other. Carrying forward the illustration, let it be supposed that every one of the hundreds of bodies constituting the Solar System is in this manner connected with the Sun and with each other, and that hold of each rope is a man whose pull is as strong as we know that of gravity to be. Now, observe how any one of these men must comport himself. In the first place he must lay out his strength proportionally to the combined mass of the two connected bodies. Then he must expend it in inverse proportion to the squares of the distances of the bodies. The nearer the approach, the stronger must be his pull, and the further the recession, the less strength will he have to lay out; and this difference is such that if the distance is halved his pull must be four times as great, if doubled only one fourth as great, and if tripled only one ninth as great. Again, it will be observed that to keep his pull regulated to such proportional distances he will have to take in rope on all approaches, and let out rope on all recessions. And the taking up and letting out of rope will itself be proportional to the strength of the pull, because the speed of the approach or recession will be so proportioned. The rope must all the time be kept taut under the strain as measured according to the above principles. This may be further illustrated by the man on the shore pulling at the boat. If he keeps the pull equable he must take in rope faster and faster as the continuous pull induces continually increased speed of the boat towards the shore.

§ 195. And turning to the astronomic illustration, it is evident that there can at no moment of time, be any letting up of the pull or relaxation, save what is required on the above principles. Through all the moments, all the days, all the years, and all the ages, the man must keep his line taut by a continuous exertion of muscular power. Never once can he give his muscles rest or play. It follows as a first corollary that he must all the time be laying out and expending muscular energy. All the time he is transferring power from his contractile muscles through the fibers of the rope to the distant body in amounts proportioned as above indicated, to be there composited with the like energies transferred through other lines from the muscles of other men on other orbs.

§ 196. Another corollary, is that, being a man, his continually expended muscular strength must be continually resupplied, he must eat and drink, and breathe, must run a furnace and power factory within his own body. Otherwise his hold on the rope will quickly slacken, and his pull on the distant world cease.

And if we suppose the pull on the rope to be exerted by the muscles of a strong horse, the result is the same. He must have hay, and oats, and water, and oxygen, and of these he must manufacture energy to transfer, unceasingly, through the medium of the rope, on the world at which he his tugging.

Or, if we suppose the power to be exerted by a steam-engine, we come to the same point. It must be fed with wood and water, and that continually and through all time. If either the fuel or the water should for a moment be cut off, all strain upon the rope would instantly cease, and the connection between the two orbs sever. And just as it must be with our imaginary man, or horse, or steam-engine and rope, so it must be with Gravity. There is a necessary continuous expenditure of power; but a continuous expenditure is possible only as based upon a continuous supply. Of course, Observation is blind and Science dumb when it comes to accounting for the manner and origin of such continuous supply of power. Here we are on the very brink of knowledge, the very edge of the abyss of profound ignorance, where Fact yields absolutely to Theory.

§ 197. But extending our illustration, we may get a yet fuller comprehension of the *modus operandi* of Gravity, by supposing on every atom of matter as many little men, or little horses, or little steam-engines as there are atoms within the sphere of Gravity, each with little cords attached to every other atom, and pulling with a power inversely as the squares of the distances, so that each atom in the universe is attached to and being pulled towards every other, and any actual motion is the resultant of all these minute unceasing pulls composited according to the law of the parallelogram. And not only so, but on each atom is there a continuous expenditure of the power transmitted by all the little men, or horses, or steam-engines, on all the other atoms; and these little men must have bread and meat, the little horses hay and corn, and the little engines coal and water, to supply the waste of power transferred through the little cords to the other atōms. And as with our imaginary sources of power, so with the Gravity actually resident in each atom. It exerts a continuous expenditure of force on or towards every other atom, and this expenditure must be kept good.

And the principle will be the same if we suppose our motive-power, our man, horse, or engine, on the world or atom to be on the moving atom or world instead of on the one towards which it moves, to be propelling instead of pulling, driving instead of drawing. There must be the same expenditure of energy and the same recuperation, and that everlastingly. There must also be the same continuous compositing of these motive-powers, or rather of the tendencies to motion, directly according to the masses, respectively, and inversely as the squares of the distances with an actual motion, the resultant of all these tendencies, of all these pushes or propulsions.

Of course, these views are at broad variance with received scientific and popular opinions; but it is sub mitted that an exhaustive analysis shows them to be not only just, but necessary and inevitable. And, as before remarked, they are in diametrical conflict with the doctrines of Conservation, and therefore with Mr. Spencer's system.

CHAPTER X.

LAWS OF FORCE AND MOTION.

MOTION—HOW CAUSED—CLASSIFICATION—UNIFORM—ACCELERATED—RETARDED—VELOCITY—MASS—MOMENTUM—MEASURE OF FORCE—KINETIC FORCES—MOLECULAR FORCES—IMPACT—PARALLELOGRAM OF FORCES—FORCES LOST—COMPOSITION—DIAGONAL—SINGLE IMPULSE COMPOSITED WITH CONSTANTLY RECEIVED FORCE—CIRCULAR MOTION—LAWS OF FALLING BODIES—DISSIPATION OF FORCES—ORBITAL MOTION OF PLANETS—RESISTANCE—GRAVITY THE SAME IN PRESSURE AS IN FALLING BODIES—ACTION AND REACTION—CIRCULAR MOTION—PLANETARY MOTION.

§ 197. Place will now be given to certain laws of Force and Motion, in order to a better understanding of the discussions to follow. While many of them will tend to elucidate the principles of Gravitation just considered, their introduction ahead of the chapter on that subject, would hardly have been beneficially practicable.

§ 198. Motion is a translation from point to point in space, caused by Force actually present in the moving body.

§ 199. Motion is either uniform, accelerated, or retarded; and both acceleration and retardation may be either uniform or irregular.

§ 200. Retardation is caused by resistance.

§ 201. Resistance may arise either from the communication of the moving force to other bodies or masses of matter, inert, or with less motion than the communicating body, or from the opposition of other forces acting on different lines of motion.

§ 202. Unresisted motion is uniform and in right lines.

§ 203. Uniform, rectilinear motion is produced by the operation of a single impulse of force.

§ 204. Uniformly accelerated motion is produced by uniform increments of force, that is, by the addition in equal times of equal amounts of force acting on the same line and in the same direction, as illustrated in the action of gravity on falling bodies.

§ 205. Uniformly retarded motion is caused by equal amounts of resistance applied in equal times,—that is, in equal times equal amounts of moving force are utilized and thereby lost to the moving body in overcoming resistance, as illustrated in the ascent of bodies against the resistance of gravity.

§ 206. Velocity is the rate of motion, or the speed of a moving body per unit of time.

§ 207. Mass is the amount of matter in a body. In terrestrial bodies it is measured by its weight or gravitative pressure towards the ground.

§ 208. Momentum is the power of a moving body to overcome single measures or propulsions of resistance, and is measured by taking the product of mass into velocity.

§ 209. *Vis viva* is the power of a moving body to overcome continuous increments of resistance. Here *time* becomes an element in the calculation, for the greater the velocity the shorter the time of action, and the less the resistance to be overcome per unit of time. Hence the law:

§ 210. *Vis viva* is as the square of the velocity.

§ 211. In uniform rectilinear motion, that is, pure unresisted translation through space under a single impulse of force, with the same mass, velocity is proportional to the force acting, and the one may be considered the measure of the other.

§ 212. As a corollary to §§ 208 and 209, momentum is the measure of force acting in any moving body.

§ 213. In uniform rectilinear motion, with the same force, velocity is inversely proportional to the mass, that is, half the mass will have twice the velocity, and twice the mass, half the velocity.

§ 214. A moving force (called also Kinetic force or molar force,) may, by impact, be transferred partially or wholly from the moving body to other bodies, moving, or stationary.

§ 215. If body A weighing 20 lbs, and moving with the velocity of 20 feet per second, that is having momentum or measure of force 400, impinges upon a stationary body B, of the same weight, they will both move forward with velocity 10. If the stationary body have mass 40, the common velocity after impact will be but 6⅔; but if B has only mass 5, it will be 16 feet per second.

§ 216. The *quantum* of force present and acting is the same after impact as before, but it is distributed and equalized to a greater weight of matter. It follows that the momentum before and after impact is the same, and that the velocity is measured in the same way, that is, by taking the quotient of mass into momentum.

§ 217. If body A impinges upon B, the latter moving on the same line, in the same direction, and with velocity 10, they will move forward together with velocity 15. Here the swifter body imparts one-fourth of its moving force to the slower, equalizing velocities, but leaving the sums of *momenta* before and after impact the same.

§ 218. If body A meets B, of the same mass and velocity, going in the opposite direction on the same line, all kinetic motion will be destroyed; and the same result will follow if B has twice the mass and half the velocity, or half the mass and twice the velocity. That is, when two bodies having the same *momenta* meet on the same line, going in opposite directions, the kinetic motion is destroyed.

§ 219. If B has the same mass and half the velocity, they will together move forward in the direction of A's motion, with velocity 5. But if B has the same velocity with A, but only half the mass, the common velocity will be 6⅔. In each case A parts with momentum, in reality force, in overcoming B's momentum, to an equal amount, to wit 200. But in the first instance the remaining measure of force, 200, is equalized to the combined mass 40, while in the latter the combined mass to which the same *quantum* of force is equalized, is only 30.

Parallelogram of Forces.

§ 220. If the two bodies moving in right lines at angles to each other, collide, they will move on together on a line which will be the diagonal of a parallelogram, whose angles will be the angles of intersection of the lines of motions and whose sides will be respectively represented by the product of each mass into its own velocity, that is by its momentum. This is the great and universal law of the Parallelogram or Composition of Forces. It may be differently expressed: If a body is acted upon by two forces not in the same right line it will move on the diagonal of a parallelogram whose angles are the angles of the lines of intersection of the forces, and whose sides will be respectively represented by the two forces. And in each case the new velocity will be to the old *momenta* or forces, respectively, as the diagonal is to the two sides respectively. Thus, if the forces acting at right angles be respectively as 3 to 4, the new motion will be the diagonal of a rectangle, whose sides are respectively 3 and 4 and the body will move over this diagonal, 5, in the same time that under the one force it would have moved over 3 and under the other over 4.

§ 221. So the body not only takes a new direction, but gains velocity with a loss of force. Before the synchronous action of the two forces upon the body, this value was $3+4=7$, after it will be only 5. If they should act in the same direction the velocity would be $3+4=7$, if in opposite directions $4-3=1$, but acting at right angles, it will be $\sqrt{3^2+4^2=5}$.

§ 222. When two equal forces meet at an angle of 120° the diagonal and all the sides of the parallelogram are equal, and the new force or velocity just equals either of the old. In this instance, just one half of the two old forces is lost.

§ 223. If with two equal forces the angle of impact is greater than 120°, the diagonal will be less than one side and the velocity less than either of the old velocities. Here more than half the sum of the two original forces is lost.

§ 224. When two forces act simultaneously on the same body at an angle of less than 120° the new velocity, and of course the new force which it measures, will be greater than the larger of the two original velocities or forces from an infinitesimal quantity up to the addition of the full amount of the smaller force where the angle of direction is reduced to 0°.

§ 225. *Contra*, when two forces act simultaneously on the same body at an angle of more than 120°, the new velocity, and force which it measures will be less than the greater of the two original forces, from an infinitesimal quantity up to the full amount of the smaller of the two forces where the angle is increased to 180°.

§ 226. It follows that from motion on the same right line in the same direction, in which case the angle is 0°, and the whole intensity of the two forces are to be added to obtain the measure of velocity, up to direct opposition on the same line where the angle becomes 180° and the smaller force has to be subtracted from the larger to obtain such measure, the principle involved is strictly the law of the parallelogram; it is all the time a composition of the two forces, with a loss from the sum total.

Circular Motion.

§ 227. When two equal forces act upon the same body at right angles the motion describes the diagonal of a square. Now by increasing the angle of incidence and simultaneously diminishing one of the forces, the diagonal may be retained in length and direction, but not as of a square, but of a rhomboid, and it still represents the moment and direction of the composited force.

§ 228. Generally, in any rectangle or rhomboid, the diagonal may be retained in length, but with different direction and sides, when one of the forces and the angle of incidence are correspondingly diminished; that is to say, there may be a composition of forces without acceleration of velocity where there is a diminution of one of the forces corresponding to a diminution in the angular incidence.

§ 229. The diagonal in all these cases represents the composited force, or, with mass constant, what is the same thing, the velocity after impact or composition. Therefore, in all these instances, where the diagonal remains constant with antagonistic forces varying in direction and intensity, the velocity remains the same by reason of the fact that the *quantum* of force resulting from composition remains constant.

These laws (220 to 229 inclusive), need some further discussion here, for it is claimed that there is no true composition of forces in the phenomena, but only the results of the simultaneous action of different forces on their own respective independent lines of motion. Thus, it is said, each force carries the moving body just as far in its own direction when acting simultaneously with another as it does if acting alone. But this is true only where the forces act in lines at right angles to each other. In such instances, if they stood alone, it might be claimed that each force, acting independently, contributed to the resulting motion. But in all other instances the resultant is different from what it could be, (either greater or less), if each force had its full independent action, thus demonstrating that in all such cases some part of one or both of the forces fails of effect, is lost in composition.

§ 230. When one of the forces is a single impulse or measure of kinetic force, and the other is a continually augmented force at right angles, and parallel with itself, the motion will be accelerated, and the path parabolic; and, if the second force starts at zero, a diagonal of a square of which the kinetic force represents one side will be a cord of an arc of the curve, that is to say, the path will pass through the opposite angle of such square, at which point it will be that the two forces will just balance, one-half of each having been lost in the composition. This is illustrated by a cannon ball shot horizontally from the top of a high tower or precipice, where gravity acts in lines sensibly parallel.

§ 231. In such case as § 230, when the constantly augmented force acts towards a fixed center, thus varying in direction at every point instead of on lines sensibly parallel, the path will be the arc of a circle, there will be no acceleration, and the two forces will exactly balance in one-eighth of the circumference. The reason there will be no acceleration is that, "the motion is through the diagonals of an indefinite number of minute parallelograms formed by every part of the circumference of the circle," and these parallelograms will be rhomboids, one side represented by the forward kinetic force called centrifugal or tangential, and the other by very minute portions of the central force acting at minute angles of incidence; or, rather, portions of such force acting through very short periods of time, and with correspondingly small incidental angles, so that, in each case, the diagonals are just equal to the longest side, and equal to each other. When the body has made one-fourth of the periphery of the circle, it passes through the opposite angle of the square, one side of which is represented by the kinetic force, known as the centrifugal or tangential force. At this point the direction is at right angles to the original motion, so that in fact the whole of the original direction is lost; there is left the same velocity, but on a perpendicular line.

§ 232. This is the law (§ 231), approximately, of the composition of forces in planetary revolutions. The modified original tangential impulsion represents one of the sides, and the constant increment of gravitative force towards the centre of motion, the other sides of infinitesimally small parallelograms in a continual recomposition, where, of course, the two compositing forces are being continually dissipated. Were the orbits of the planets exact circles, with the sun in the centre, this law would exactly apply to them, but since the paths are only ellipses, with the sun in one of the *foci*, it happens that at only two points, the perigee and apogee, are the two forces at right angles, and at these two points they are not equal in measure. As a result of these conditious the motion of the planet is accelerated in one-half of its orbit, and retarded in the other half. And this shows that the proposition often announced that the only office of gravitation in planetary motion is to *bend in* the path of the body, cannot be true. For it must be conceded that it is gravity which first hastens and then slackens orbital motion, that to it is due acceleration and retardation.

§ 233. The error on this point seems to arise out of erroneous notions of Inertia. Thus Prof. Tait says: "The old notion was that a centripetal force was required to balance the so-called centrifugal force, it being imagined that a body moving in a circle had a tendency to fly outwards from the centre! Newton's simple law exposes fully the absurdity of this. If a body is to be made to move in a curved line instead of its natural straight path, you must apply force to compel it to do so; certainly not to prevent it from flying outwards from the centre about which it is for the moment revolving. In fact, the *Vis Inertiæ*, now called *Inertia*, means not revolutionary activity, but dogged perseverance; and just as you must apply force *in* the direction of motion to change the *rate* of motion, so must you apply force *perpendicular* to the direction of motion to change that *direction*."—*Advances in Physical Science*, p. 350.

This is all clear, and would no doubt have been so modified as to have expressed the facts, had Prof. Tait grasped the true principle of Inertia; that the forward motion is caused by present force, which does all the time tend at every point to drive the body off on a tangential line, instead of being merely a "dogged perseverance."

§ 234. But it will be observed that when the body has accomplished just one-half of its quadrature, its direction is at an angle of 45 degrees from that of the initial point, that is, it is just midway the perpendicular lines of the forward kinetic direction and the central pull at the start. So it must be, that at this point the constant single kinetic centrifugal impulse, and the constant central accretive tendency have just equaled and balanced each other, with the consequent equal dissipation of each to the amount of one-half.

An amount of gravitative force has been supplied in the one-eighth revolution, just equal to the initial tangential impulse, but, by the continuous recomposition and consequent dissipation of the two forces in equal quantities to the amount of one-half the sum total, it remains the same, and, consequently, the velocity the same, the result being that the path is the arc of a circle of 45° amplitude, and the direction is changed by an angle of 45°.

Law of Falling Bodies.

§ 235. A body falls in one second, omitting fractions, 16 feet; in two seconds, 64 feet; in three seconds, 144 feet; in four seconds, 256 feet, etc., the distance fallen being proportioned to the squares of the times of falling. In the first second it falls 16 feet, in the second second 48 feet, in the third second 80 feet, in the fourth second 112 feet, etc. That is, the distance fallen in successive seconds, are as the odd numbers 1, 3, 5, 7, etc. The reason of both these principles is found in the accumulating character of the force of gravity. A body commences its fall with no velocity, but the gravitative force it receives during the first second gives 32 feet per second velocity at the end of that time. But starting without velocity, and attaining 32 feet in the second, the distance fallen in such time can only be the average velocity for the whole second, that is, 16 feet. In the second second there is the same reception of gravitative forces, so this period commences with 32 feet and ends with 64 feet velocity per second, the average being the mean between, to wit: 48 feet, and this is the distance fallen in the second. The third second commences with 64 and ends with 96 feet velocity, the mean being 80 feet the distance fallen in the second. The fourth second commences with 96 feet, and attains to 128 feet, the mean and distance fallen being 112 feet. We have then, fall in first second, 16 feet; adding 48 feet, the fall of the second second, we have 64 feet for the fall of the two seconds. To this add 80 feet the fall of the third second, and we have 144 feet for the three seconds. So 112 feet added for the fall of the fourth second gives us 256 feet for the four seconds, etc. Differently stated, the distance fallen is equal to half the velocity at the end of the time, multiplied by the time.

§ 236. In a body rising by any projectile force, gravity acts upon it according to the same laws in reversed order, retarding the motion at the rate of 32 feet per second. If it starts upward with 96 feet velocity per second, it will be retarded 32 feet in the first second, so that period will end with a velocity of 64 feet per second. Now, the distance it will ascend in this first second will be the average between the initial velocity of 96 feet and the final velocity of 64 feet, to wit: 80 feet. The retardation in the next second will be the same, so that, commencing with 64 feet, it will end with 32 feet per second, the rise being the mean between them, to wit, 48 feet. The third second, experiencing the same retardation, it will commence with 32 feet and end with 0, the rise being 16 feet the average between. So the distance of the ascent in the three seconds is: 80 feet+48 feet+16 feet = 144 feet, the exact distance through which it would have fallen in the same time.

Therefore, gravity will, in the same time, destroy the same measure of motion in an ascending body that it will give in a descending one, and the height to which it will ascend against gravity will be proportioned to the square of the velocity. "When a body projected upward has reached the highest point, it will fall backward and its velocity at any point through which it passes twice will be the same in going up and in coming down." *Deschanel*, p. 59.

The distance over which a body will move against any other constant resistance is as the square of its velocity, and for the same reasons. Thus a ball fired into a block of wood will penetrate four times as deep with twice the velocity. This is a different statement of the law of *vis viva*. §§ 209, 210.

But this law holds under two conditions only; to wit, the resistance to be overcome must be uniform and constant, and the whole of the force exerted must be expended in doing the work.

§ 239. Gravity acts in pressure on stationary bodies on the same principles as on falling bodies. This appears from various considerations amongst which is Torricelli's Theorem, thus stated by Deschanel: "If an opening be made in the side of a vessel containing water, the liquid escapes with a velocity which is greater as the surface of the liquid in the vessel is higher above the orifice, or to employ the usual phrase, as the head of a liquid is greater."

§ 240. Action and re-action are equal and opposite. "Whenever a body is acted on by a force, the body from which this force proceeds is acted on by an equal and opposite force." *Deschanel, p.* 45.

The above proposition is Newton's third law, and is applicable to systems of bodies controlled by gravity and generally to impacts, strains and elasticity. But it is not safe to affirm the universality of the law, not at least without modifying and qualifying terms.

§ 241. The law of the parallelogram is applicable to any number of forces acting synchronously upon a body, and the resultants or actual motion will be in that line and with that velocity left as the residuum from the loss of the various forces by reason of their mutual opposition in composition.

Law of Circular Motion.

§ 242. In circular motion, the force necessary to be exerted centripetally is represented in velocity per second, by dividing centrifugal velocity by one eighth of circumference. This is a corollary to § 234.

Deschanel states the current scientific view thus: "In circular motion the force necessary to be exerted centripetally is represented in velocity per second, by dividing the square of velocity by radius." Page 59.

Both propositions bear just proportions to the law of gravitative force, that is, in any astronomical system as the solar system, gravitative force found either way is inversely as the squares of distances.

§ 243. But that the law as stated by Deschanel cannot be correct is obvious from several considerations. In the first place, he, following Newton, bases his demonstration upon the hypothesis that the arc of the circle and the corresponding tangent for short distances are sensibly equal. Of course when the distances are taken small enough this is practically true, that is to say, the difference becomes inappreciable to our modes of measurement and it may be even to our modes of expression. But it is evident that a difference in length cannot be wholly annihilated by subdivision, and that, however minimized, it must again become appreciably present when used as a basis for calculation for large measurements. In other words, however small the differences the arc and tangent can never be exactly the same and the difference must increase in exact proportion to the number of the repetitions or multiplications in calculation. If the distance taken is so small that the difference is only the one hundred millionth of an inch, when it shall be multiplied by one hundred million the error becomes one inch and multiplied by one hundred million more it becomes over 1,500 miles.

Again, the proposition of Deschanel is founded upon the further theory that the centripetal force acts on parallel lines, which is never true; but, on the contrary, on lines which change direction at every point; and this, as has been seen, is the difference between circular and parabolic motion (§§ 229, 230, 231.) With central force acting on lines continually parallel, circular motion would be impossible. Of course, then, no correct theory can be founded on such basis.

This proposition also assumes as foundation that in circular motion there is *a fall* towards the centre which of course is not true. As every point in the periphery of a circle is equally distant from the centre there can be no fall from it. The only fall there is, if it may be called a fall, is from the tangential line.

Another assumption involved in this theory, is that in the *fall* there is an acceleration. "We distinguish between the intensity and the amount of a force. The amount of the force of gravity upon a mass of *m* grammes is *mg* dynes. The intensity of this force is *g* dynes per gramme. The intensity of the force, in dynes per gramme of the body acted on is always equal to the change of velocity, which the force produces per second, this change being expressed in centimetres per second. In other words the intensity of a force is equal to the acceleration which it produces. The best designation for *g* is *the intensity of gravity*." *Deschanel*, p. 51.

That is, gravity is regarded as an accumulative, and accumulating force. But this is not correct in circular motion for the reason that it is lost in recomposition with centrifugal force as fast as received.

§ 244. It remains, then, that the amount of the continual reception of gravity in half a quadrature is just equal to the whole single impulse of forward centrifugal force with which it is composited with the only result of changing the direction of the motion 45° in that distance. In other words, gravity, in quantity equal to the propulsive force, is spread over one eighth of the orbit, equal amounts in equal times; so that, counting from any particular point in the orbit, at one eighth the circuit the propulsive force is one half original and one half gravital; at one fourth the circuit it is one fourth original and three fourths gravitation. When three eighths of the circuit is accomplished it is only one eighth original force and seven eighths gravitation, when one half is accomplished it is 1-16 and 15-16 respectively. When the whole circuit has been made the original propulsive force has been reduced by eight recompositions to 1-256, while gravitative force has taken its place to the amount of 255-256. Thus eight times has gravitative force been supplied in quantity equal to the centrifugal force, and eight times has an equal quantity of the composited forces been dissipated and lost.

And thus do the revolutions of all astronomic bodies contradict Conservation and invalidate Mr. Spencer's system of philosophy.

CHAPTER XI.

ORBITAL MOTIONS.

ORBITAL MOTION OF MOON—OF EARTH—PLANETARY MOTION.

Moon's Orbit.

§ 245. It is said in the standard works on astronomy that the Moon revolves around the earth in a little more than 27 days, while, at the same time, it sweeps around the Sun with Earth in one year. This is giving her a velocity around the Earth of about 2,000 miles per hour, and around the Sun of about 66,000 miles per hour. If Earth were pursuing a rectilinear path through space, it is clear the Moon could not surround her but that gravitation would soon bring them together in collision. That a correct notion may be obtained, let us, for the moment, disregard the common motion around the sun, when commencing with the first quarter of the Moon, we have her crossing ahead of Earth in her orbit, and moving at about the same rate, 66,000 miles per hour. But gravity continually pulls her back and slows her motion down; in less than 4 hours Earth passes over her late position; at full moon 7 days after, Earth has gained on her so as to be alongside, between her and the Sun, and the slowing up has been so decided that her motion is now considerably less than Earth's. But, as she continues to fall behind, gravity begins to quicken her speed, until at the last quarter she drops into Earth's path nearly 4 hours behind, and with speed increased to the same rate. Gravity continuing now to hurry her up, at new moon, she gets along side of Earth again, but on the inside next the Sun, and with a speed considerably in excess of that of Earth. But as she hurries on past, gravity commences to slow her down again and draw her in ahead, where she again crosses Earth's path in about the same speed and nearly 4 hours in advance. Now during this so called revolution from first quarter to first quarter, from one node to the same again, Earth has travelled about 45,000,000 miles, and the moon has made the same average rate, or a little more, sometimes being faster and sometimes slower, at an average distance of 240,000 miles, sometimes that far ahead, sometimes that far behind, sometimes to one side, and sometimes to the other. Her path is really that of an elongated spiral. Says Mr. Lockyer: "The total departure of the Moon from Earth's orbit, however, does not exceed 1-400 of the radius of Earth's orbit; so that, unless drawn on a very large scale, the orbit of the Moon would appear to be identical with that of the Earth."—*Elements of Astronomy*, p. 115.

§ 246. So, as a matter of fact, the Moon does not revolve around the Earth in such sense as is generally conceived, but both Earth and Moon revolve about the Sun in paths so nearly identical that the Moon is by gravity continually pulled back and shot ahead so as to place her on all sides of Earth.

§ 247. Now here are three forces to be accounted for in composition: first her forward propulsive motions of about 66,000 miles per hour, next her gravity towards the Sun, and then her gravity towards Earth; and her motion at any moment is the result of the composition of these three forces, with a continual dissipation or loss of the sum total and a continual resupplying of gravitating force in the two tendencies towards Sun and Earth. Were Earth stationary and had the Moon only a propulsive force of about 2,000 miles per hour, her gravitating force towards Earth would carry her around in a true orbit, as is now generally supposed to be her actual motion. In this case there would be but two forces to be composited.

§ 248. As has already been remarked, were Earth and the Moon pursuing a rectilinear course through space, they would inevitably collide, for, whether we suppose the Moon ahead of Earth, or at the opposite node moving with the same speed, or on the right, going slower, or on the left, going faster, as she could never surround or make an evolution about Earth, her gravitative tendency would inevitably precipitate her upon Earth. It is the gravitative force of both towards the Sun which enables them to pursue nearly the same path with nearly the same onward speed without collision. And nothing can be conceived grander, more beautiful, or more wonderful, than the harmonious correlation of movements of Earth and Moon relative to the Sun.

Motion of Solar System.

§ 249. This matter has been dwelt upon at length for the purpose of illustrating and enforcing a proposition with reference to Earth and the other primary planets. It is this: Astronomers seem to be very generally agreed that the Sun, with the whole Solar System, has a progressive motion through space. Now if this be true, such motion must be about some great attractive centre towards which Sun and planets have a gravitative tendency. For, otherwise, in order to present the appearance of orbital motion around the Sun, the planets must severally move sometimes their whole apparent velocity slower and sometimes that much faster than he, so that, in reality, they are pursuing paths which are elongated spirals with very varying velocities, and there is nothing to prevent their precipitation upon his body.

Were such the case, the forward propulsive motion of Sun and planet, with the gravitative tendency towards each other, would not so composite as to produce a balancing or compensating motion which could keep them apart. This can only be done by a gravitative tendency of both towards a central body which, compositing with their forward propulsive motion, gives them circular or elliptical paths. If this be the case, therefore, Earth's tangential force composites with two gravitative tendencies, one towards the Sun, and one towards the Great Centre, wherever, or whatever that may be, and her actual motion is the resultant of these three forces. And, of course, according to the great law of the Parallelogram and the principles of Gravitation, there is a dissipation with a continual re-supply on the gravitative side.

§ 250. And so, if the astronomers are correct about the motion of the Sun, the Moon is subject to a still more intricate compositing. Not only has she her tangential motion, but her tendencies towards Earth, Sun, and Great Centre. Her path runs continually spirally across Earth's, the paths of the two spirally across the Sun's, and all together sweep around the Great Centre with unknown velocity, and the Moon's actual motion at any moment is the result of the compositing of all these forces, with consequent dissipation and re-supply.

§ 251. If Prof. Newcomb is correct in his opinion that the star Groombridge, 1830 is traversing space in a right line, it cannot be a sun accompanied by a retinue of worlds, but must be an isolated and independent body.

§ 252. It should be remembered that, to limited extents, both Earth and Moon have gravitative tendencies towards all the other planets, primary and secondary, and, for aught we know to the contrary, towards all the stars as well, and that their actual motions are the result of all these tendencies; or, otherwise stated, the actual motion at any moment is produced by a force which is composited of the forward propulsive force, whether that be around Sun or Great Centre, and of all the gravitative tendencies towards all the centers, whether one or many, as well as towards all other masses of matter within the reach of Gravitation. All these forces and tendencies are composited according to the parallelogram, with consequent dissipation and re-supply, and a resultant of direction and intensity, which gives the motion of the particular orb at any particular moment.

§ 253. The orbits of all the planets are elliptical. As a consequence the orbital motions of none of them are uniform, sometimes they are ahead, and sometimes behind the average. This arises from the fact that sometimes they are so situate that the gravitative tendency towards the central orb hastens them forward and sometimes holds them back; sometimes in the composition the gravitative force is partially added to the propulsive and sometimes partially subtracted from it, that is, sometimes the resultant is greater than the larger of the two original forces and sometimes less.

§ 254. Thus every motion of every one of the heavenly bodies contradicts the theory of Conservation on the two essential propositions that no old force is ever lost and no new force ever found. But, on the theory of Conservation, Gravitation is inexplicable; no rational explanation can be given of it, nor can it be true that it causes and compels all planetary movements.

CHAPTER XII.

MOLECULAR FORCES.

IMPACT—PRESSURE—ELASTICITY—PULLS — MUSCULAR FORCE—COHESIVE FORCES EXHAUSTED—AND CONTINUALLY RENEWED—THE LEVER—ELASTICITY—CROSS-BOW—RUBBER CORD.

Impacts.

§ 255. In all solid bodies the smallest parts, atoms, molecules, or particles, are held together and held apart by what are called molecular forces. Through these forces all pressure from without is passed, as well as all pulls, stress or strains. But if the extraneous force which exerts the pressure, pull, push, stress, or strain, should excel the tenacity of the molecular forces of the body upon which the extraneous force is exerted, the body will be crushed if a pressure or push, rent if a pull or strain.

And time becomes a very material factor in these molecular resistances, for it seems to constitute the element of difference between impact and pressure. The more rapid the communication of the exterior force the greater the crushing or rending effect, because the less time is allowed for conveying the force away in the form of pressure.

§ 256. This principle presents itself in various lights and may be variously illustrated. If a ball of cast steel be thrown against a wall, when the motion is arrested by the contact on the side next the wall, the molar force in all the other particles pass instantaneously through the molecular forces holding them together, so that the whole force is delivered against the face of the wall at the same instant, sensibly, and in shorter time than it can all be conveyed as pressure. The consequences vary with the character of the wall. If fragile, the particles in front of the ball may be driven bodily away, that is, the force of the ball may be passed as kinetic force, or, perhaps, as pressure instantly reconverted into kinetic force to the particles in front of it, setting up motion in them; or the particles may be compressed in front of the ball into smaller space, the cohesive forces being overcome to a degree, permitting limited molar motion and transmitting part of the force of the ball as pressure. Or if the wall be of firmer texture a part of the force may pass through it as pressure and a part as vibrations. There is also, generally, a greater or less development of heat, not now to be considered. If the ball thrown be soft clay or putty, when the motion is arrested and the kinetic force in the rearward particles press forward, the molecular forces holding them together are overcome, and the particles pass on and are flattened against the wall. But the time consumed in their doing so, affords opportunity for the force of impact on the near side to have already been passed as pressure through the wall, and the result is very different. Although the two balls move with equal velocity, they do not apparently strike with the same force, because in the first illustration the force is all delivered in the same instant, while in the latter the communication covers a much longer time, comparatively.

Elasticity.

§ 257. This, with another principle is illustrated when a rubber ball is thrown. Here, also, by reason of the facile character of the particles of the rubber, the back portions of the ball are, upon impact, carried bodily forward upon the front particles, time being consumed in the operation, so that the force of impact has time for distribution as pressure. But here elasticity comes into notice. Cohesive force gives way so far as to let the hindmost particles move on the foremost to a greater or less extent, but recovering their tension in an inappreciably short period of time, they drive the hindmost particles back again, and that with such power that it is converted into kinetic force, carrying the ball away with almost its first velocity.

§ 258. Elasticity is never manifested except as resistance to other forces. In the unbent bow, the unstretched rubber cord, or the uncompressed steel spring, or rubber ball, you see none of it. And it may appear as resistance to compression as in the bow, the spring, or the ball; or, to strains or pulls as in the rubber cord.

Pulling Forces.

§ 259. It may be noticed that a pull is the same in whatever way made. It may be by gravity through a suspending cord, it may be by the tension of the muscles of the arm, or it may be by the drawing of a stretched rubber band, or it may be by means of the elasticity of a spring. In either case the moment of the pull may be regulated to the same tension; then the work done by each will be the same; that is, they will each lift the same weight or draw the same load. Not only so, but they exert equal strains upon the cords by which the pulls are made, and if the cords are of equal strength they will sever at equal tensions.

§ 260. And further, in each case, the pull antagonizes, and is antagonized by the cohesive forces of the cord at every point, and when it parts it will be at the point where cohesion is weakest. This verifies the adage that "the strength of a chain is the strength of its weakest link."

§ 261. And here, as before, while the behavior of these pulling forces is precisely the same, there is this difference in the phenomena: after a time the arm becomes fatigued and refuses to transmit more force until it has rested, whereas the other sources of power do not become fatigued, at least gravity not at all and elasticity not in any short period. They impart force alike because they pull alike; the arm soon imparts all it has and becomes exhausted, the others continue to impart without exhaustion. One of two conclusions inevitably follows: either in the weight, spring, and rubber cord, new forces are continually growing up as they are given out, or else each possesses an inexhaustible store of force, and is capable of giving out continually without any diminution of the stock.

§ 262. And the same principle may be illustrated in another way. The compression or strain may be steam power, which will last only so long as fuel and water are supplied to the engine; that is, a continual supply of force must be furnished to the engine to enable it to keep up the pressure or tension. But all the time of this continuous supply of energy on the one side, the elastic resistance continues on the other. To one there is a visible supply, a measurable contribution; there must be an invisible continuous supply on the other side, or else there is, in every elastic body, an inexhaustible, a practically infinite store of force.

§ 263. The pull may be of 100 pounds moment while the cohesive strength of the cord is an ounce more; the strain may thus continue for an indefinite length of time, but during all such time 100 pounds moment of the tension of the cord is balanced and overcome by the pull, so that only a single ounce of tension is left; and if an ounce more is added to the pull that too will be overcome and the cord will sever. All the time of the hundred-pound pull, the strength of the cord is reduced to one ounce; the moment the pull may be slackened the cord resumes its original strength of 100 pounds and 1 ounce. That is, the 100 pounds of tension is overcome forever at the weakest point if only another ounce is added; but if, instead of adding the ounce to the pull, the 100 pounds is taken off, instantly the tension of the string grows up to 100 pounds 1 ounce. This seems to show, conclusively, that all the time of the pull, the strength of the cord is being exhausted and as continually growing up again. And what is true at the weakest point of the cord is true at every point; at every point the pull is resisted 100 pounds, 100 pounds moment of the tension is overcome and exhausted in the resistance, while an equal amount is continually growing up to supply its place. So that this remarkable phenomenon is presented: while but one continuous moment of 100 pounds tension is transmitted as the pull through the fibres of the cord, this single tension acts upon the cord at every point to the extent of diminishing its cohesive tension 100 pounds; at every point 100 pounds of cohesive tension is overcome and the same quantity grows up to supply the loss.

§ 264. Prof. Tait says: "Pull one end of a long rope, the other being fixed. You can produce a practically *infinite* amount of force, for there is stress across every section throughout the whole length of the rope. Press upon a movable piston in the side of a vessel full of fluid: you produce a practically infinite amount of force, for across every ideal section of the liquid a pressure per square inch is produced equal to that which you applied to the piston. Let go the rope, or cease to press on the piston, and all this practically infinite amount of force is gone."—*Recent Advances in Physical Science*, p. 355. There Prof. Tait sees the fact clearly, but assigns the wrong interpretation. For the truth is, that so long as the pull or pressure is kept up force in the rope at every point, or in the hand, is exhausted and re-supplied.

§ 265. This is precisely as it is in gravitative pressure. Suppose a slender pedestal supporting a statue of a hundred pounds weight. That amount of pressure is continuously passed downward through the pedestal. If the latter be of fragile material it may be that the addition of another ounce would crush it. In this case, as in the last, the single volume of pressure overcomes 100 lbs. of cohesive tension at every point leaving barely an ounce intact, and this continues as long as the pressure continues, and is relieved when the pressure is removed. Here, too, there must be a continuous growing up of the cohesive forces in the pedestal to supply the continuous exhaustion. Here, too, the pressure instead of being of gravity, may be of animal muscle, or of a steel spring, or of steam, with results precisely the same.

§ 266. Not only so, but one spring may be made to act against, and oppose another almost to the breaking point of each. Here the force in each is opposed, overcome and exhausted continuously by the tension in the other and must of course grow up as continuously.

So two rubber bands or different parts of the same rubber band, may be made to act against each other on the principles just discussed, producing mutual exhaustion of cohesive tension with the necessary process of a continual growing up of a re-supply.

It may be observed, further, that it is immaterial what the pull is against, that is to what the cord is attached. The principles are the same, whether it be against a fixed and immovable object, a strong spring, the muscles of a man, or of a horse, or against gravity in the form of a suspended weight.

The Lever.

§ 267. The principles of the lever have the same basis. The pressure on the long arm is conveyed through its particles past the fulcrum to the resistance at the short end, all the time being resisted and overcoming the resistance of cohesive tension in the particles. Here, likewise, we may readily conceive of a balance of pressure for any length of time, so nearly equal to the tension at some point in the length of the lever, that the addition of another ounce would rend it. Yet taking off the whole pressure the full strength of the tension is instantaneously restored. And here, again, it must be that while the tension amongst the particles of the fibres of the lever are at every point resisted and overcome to the amount of the moment of the pressure, the tension must at the same time be continually growing up in the same measure. And here, too, it matters not what is the character of the pressure applied at the long end of the lever, whether gravitative, muscular, or that of a spring, or elastic cord, or of steam, or compressed air.

Liquid Pressure.

§ 268. And again, we have the same thing in the pressure of fluids, whether liquid or gaseous. We may suppose a vessel of water in which the texture of the vessel is so fragile that it is barely sufficient to resist the pressure of the liquid against its sides. In that condition it may rest for days, or months, though at any moment the addition of another pint of water would so increase the strain as to precipitate a rupture. Let the water be drawn off and the full tensive strength of the wall of the vessel is restored. Let the vessel be hooped with a band of iron, or a rubber cord, or a hempen rope securely knotted or held by a spring of steel, or by muscular strength, or let the arms of a man be thrown around it, in any of these ways, the sides of the vessel may be so strengthened as to resist many more pounds of pressure. In these respective cases the cohesive tension of the iron or hempen band, the elastic force of the steel spring or of the rubber cord, as the case may be, reinforces and supports the cohesive tension of the sides of the vessel; the two tensions unitedly support each other, and, unitedly, have to be overcome before the rupture occurs. As they resist coetaneously, their tensions must be overcome coetaneously and grow up in renewal coetaneously. The only difference of behavior to be noted is that after a time the strength of the man's arms or of the steam become exhausted and give way, while the strength of the other supporting tensions do not.

§ 269. It will be noticed here that the pressure of the water is gravitative and of course is continuously passed off and renewed as heretofore explained. But in a jar of gas the pressure is in part only gravitative, but mostly elastic to be hereafter explained, but the principles of the pressure and of the exhaustion and renewal of the pressure-force are the same.

The Cross-Bow.

§ 270. Cohesive forces may be further illustrated and demonstrated by the example of the cross-bow made of elastic wood. If it be bent by the hands, muscular energy is expended in the work, and because of cohesion, the particles of the timber resist, and the mutual resistence goes on so long as the restraint is continued. Now, in this effort, muscular energy is continuously applied, as is shown by the fact,that soon the hands and arms become fatigued and exhausted. But the resistance of cohesion is just as continuous, for it at no time slackens to the pressure of the hands. As long as the bow is bent it resists, but when the string is let slip, a portion of the resisting force is communicated to the arrow, which is carried forward by it, towards the mark. If the bow is bent again, it shows the like resistance, and will communicate the like projectile force to the arrow, and this may be repeated a thousand times. Now it is clear that all the force communicated to the arrow to carry it to the mark, must be each time re-supplied to the bow in the form of cohesion, and be that much new force whose antecedents are untraceable.

Elasticity and Cohesion.

§ 271. And the same principle prevails wherever elasticity is resisted. If one end of a rubber cord be tied to a weight, and the cord stretched, it will all the time pull against the weight until it is loosed, when the cord will not only draw it forward but throw it the cord's length beyond the point of attachment, and this may be repeated indefinitely. Here there is an expenditure of cohesive force each time, but, as the elasticity is not thereby perceptibly diminished, it follows that the expended force must be supplied from some source, as yet untraceable by science. The same is illustrated by a watch-spring. Each time it is wound up it expends force in running the works for twenty-four or more hours, but this expenditure must each time be re-supplied. So in the waving of the forest or fields of grain before the wind. After bending forward the elastic force of cohesion in the stems and branches causes them to move back to their accustomed positions and this is repeated myriads of times. In these backward movements force is expended, but it must be as often supplied, else the elasticity would be lost, and the trees or grain or grass would bow before the gale but once to rise again.

§ 272. Here again Conservation is set at naught. Forces are both exhausted and re-supplied. Old forces are lost, new forces are found; or, rather, there is a continual flow of force into, through, and out of all bodies suffering elastic strain or stress, from one region of the unknown to another. No other logical theory of elasticity has ever been offered and it is submitted that none other consonant to the facts can be offered. Certainly no theory founded upon Conservation can be made to comport with the facts when these are rightly understood.

§ 273. But another property of elasticity needs to be observed here. In all resistance, where *only* it manifests itself, it strives to pass into kinetic force in the production of molar or bodily motion. This is seen in the rebound of the rubber ball, in the flight of the arrow from the unbending bow, or of the ball from the spring gun, or of a weight thrown by the relaxing rubber cord. It is this struggling of elasticity to produce kinetic motion which enables the compressed watch-spring in its slow unbending to produce the movements of the interior works which cause the hands to indicate the time of day.

§ 274. And it may be noted, further, that it is through the property of resistance found in the cohesive forces in pinion, wheel, and lever, that the tendency of elasticity in the spring to pass into the kinetic mode of force is controlled, regulated, and timed. So that the action of this beautiful piece of mechanism depends, not at all on the "stored up muscular energy of the *hand* which wound it," but on the antagonism between two forms of molecular force, elasticity and cohesion. "The hand which wound it" was resisted by the elastic force present in the spring, but overcame it during the winding; but, when wound up, the reception of this force continuing, it continues its resistance, now against the cohesive forces in the mechanism instead of against the muscular force of the hand.

§ 275. Another fact may be noticed here. Gravity is all the time being received by all the exterior portions of Earth's crust, and as constantly transmitted downwards through the strata of its solid masses with a tendency to produce kinetic motion, which is prevented *only* by the resistance of the cohesive forces in those solid masses, so that everywhere in Earth's crust there are in active operation two antagonistic forces in immeasurable quantity, one of which we know by observation and experiment to be a constantly received and constantly transmitted force; and the other of which, must, therefore, be either a constantly received and constantly exhausted force, or else an infinite store of force, constantly exhausting, but never exhausted.

CHAPTER XIII.

REVOLVING MOTION.

FLY-WHEELS—COMPOSITION OF FORCES—DIURNAL MOTION OF PLANETS.

§ 276. All circular motion involves the principles of the parallelogram. Any wheel started in motion would, if it could be free from friction and atmospheric obstruction, revolve forever. This for the reason that in every moment of time the forward centrifugal motion of every point, or rather the centrifugal force at every point, is composited with the molecular force holding it towards the centre, a part of both being neutralized, and a new direction being consequently assumed in every portion of time, however short. But the molecular forces are re-supplied as fast as dissipated, so that it becomes an exact analogue of planetary motion, except that molecular forces take the place of gravitation. That this is so is proven by the fact that, if the motion becomes sufficiently rapid, the cohesive forces are overcome, and the wheel goes to pieces.

§ 277. It is common experience that a large wheel such as a grindstone, or a fly-wheel, if the hanging be true and light, when once set in rapid motion, may revolve many minutes without the application of any additional force. The current theory of circular motion in these cases is the same as that discussed relative to planetary motion. The parts of the fly-wheel, it is said, tend by reason of their inertia to fly off at every point of the circumferance in tangential lines, but are held down and continually pulled into the circular path by the cohesive forces which hold the particles together.

It will be remembered that the theory of planetary motion in this work presented, is that the forward motion of the planet in its orbit is continually composited with constantly accretive gravity, and with a consequent loss to both forces according to the law of the parallelogram. It is submitted that in the fly-wheel, also, there is a true composition of forces according to the same law. The cohesive forces holding the outer particles toward the centre composite with the force which set up the original motion at every point, with a consequent loss to each, but a constant sum total which keeps the motion uniform, except for the resistance of friction and of the atmosphere.

That this is the true explanation is shown by the fact, amongst others already noticed, that fly-wheels and grindstones under rapid motion frequently fly asunder. The forward or centrifugal force entirely overcomes cohesion and take their independent course. Now suppose a wheel will bear a thousand revolutions per minute but not a thousand and one. For weeks it may run at the speed of a thousand, all the time, of course, cohesion being overcome, all save one part in a thousand and one. If the motion is increased by that one revolution the wheel goes to pieces. But if, instead, the motion ceases, the cohesive tension immediately resumes its normal strength.

Therefore, it must be, that all the time of the motion a thousand parts of the cohesive tension were continually overcome and exhausted, while at the same time they were continually growing up to supply the loss.

The same principle is illustrated by the whirling of a leaden ball by a cord attached. The ball will pull against the cord the more, the greater the velocity, and if the motion becomes too rapid the cohesive tension of the particles will give way and the cord snap. And in the sling the same thing is illustrated.

§ 278. The diurnal motion of Earth illustrates the same phenomenon. It resists and overcomes the gravitative pressure towards the center to the extent of reducing the weight of bodies at the Equator one seventeenth. That is, bodies under the equinoctial weigh one-seventeenth less than they would do if Earth had no diurnal motion ; or, another way of stating it, is that one-seventeenth part of the gravitative force composites with the centrifugal force according to the law of the parallelogram. If the revolutions were seventeen times more rapid than they are, the central gravitative force would all be thus composited, and if eighteen times faster it would all be overcome near the equator while the surface matter would fly off in tangential lines as water flies from a rapidly revolving grindstone.

§ 279. Just as in earth's annual revolution so in the diurnal revolution around her axis : the motion is produced by a continually composited force made up of the original impulse eight times composited in each revolution with continuously received gravity. And it may be noticed as necessary consequences of this theory, if only theory it can be called, that practically, the whole force employed in diurnal revolution, just as in annual revolution, is gravitative; and further, that in the one, as in the other, there is a continual dissipation of force.

§ 280. A stick thrown from the hand may be made to revolve on an axis while moving forward on a right line. Here muscular force is imparted so as not only to propel it forward, but, by giving one end a greater forward motion than the other, to initiate a whirling motion around an axis which is kept up by a continual compositing of the cohesive forces with the original whirling impulse, and with the necessary consequences of continual receptions of the cohesive forces and the like dissipation of the two compositing forces. A thrown ball may be made to rotate in the same manner and on the same principles. This is practically illustrated in the use of the rifle in gunnery.

§ 281. And here may be noted an analogy between Elasticity and Cohesion. Elasticity does not exhibit itself save as resistance to pressure or tension. Then only it visibly expends itself and is renewed. So it is only in resistance that we become aware of the presence of Cohesion. It resists gravitative or other pressure as well as all kinds of strains and stresses, and resists all unequal tendencies to forward motion in bodies, thus compelling the initiation of revolving motions around axes, and afterwards continuing such motions by continually renewed compositions dependent upon its continual reception and exhaustion. In fixed or stationary bodies any unequal pressure or tendency to kinetic motion becomes a strain or stress only, but in free bodies it takes the form of motion around axes as above indicated. In both instances it is resisted by Cohesion but the results of such resistance depend upon the conditions of fixity or freedom. In the one it is strain or stress, in the other revolution.

CHAPTER XIV.

VIS VIVA.

DEFINITION—STEWART AND TAIT—BALFOUR STEWART—ASCENDING KILOGRAMME—BALL FIRED INTO BLOCK—DISTANCE TRAVELLED NOT THE MEASURE OF WORK DONE—VELOCITY AS THE FORCE—NEWCOMB.

§ 282. As has already been stated, § 208, momentum is found by taking the product of mass into velocity, but physicists tell us there is another property of force in action or motion, called *vis viva*;

that *vis viva* is the power of doing work, and is found by taking the product of mass into the square of velocity. But analysis will show that there is no different property of motion or force involved in the phenomena of *vis viva*, but that, on the contrary, what seems a different characteristic of force is dependent wholly upon the kind of resistance encountered and the peculiarity of the fact that the resistance overcome per second necessarily bears a geometric ratio to the velocity. This will appear in the illustrations furnished by physicists who have observed the fact that the swifter the motion of any projectile the greater the penetrating effect in nearly the ratio of the squares of its several velocities.

Profs. Stewart and Tait say: "We have said that the energy which a body contains—its *vis viva*—its power of doing work, is independent of the direction in which it is moving; and further that, while the mass is the same, it is proportional to the square of the velocity. For instance we may measure the energy of a cannon ball or of an arrow by the distance it will carry itself up against the force of gravity, represented by its own weight, when shot vertically upwards, and we find that, with a double velocity, it will go four times as high. Or we may point the cannon horizontally, and measure the energy of the same ball by the number of planks of oak-wood which it can penetrate, and we shall find that a ball with double the velocity, will penetrate nearly four times as many as one with the single velocity." *Unseen Universe, p.* 107.

In support of this proposition, Dr. Stewart says: "*A rifle ball does greater execution than the recoil of the gun.*" But this only shows that the penetrating power, which may be a very different thing from the mechanical effect, is greater. A ball with rapid motion will penetrate the deeper, but when moving less swiftly it will tear and rend the more. Did the stock terminate in a point no broader than the ball, the difference would not be so great. If it terminated in a keen knife blade, perhaps it would be about as dangerous to stand at one end of the rifle as at the other. In the next place, the velocity of the ball being great, there is no time for its momentum to be communicated to the whole object struck, and it is spent in penetrating it, whilst, with the heavier stock, the velocity being small, there is time for the force to be communicated to the whole body, and the effect is a jar.

Laws of Ascending Bodies.

Dr. Stewart thus states another argument in support of his position: " A kilogramme shot upwards with the velocity of 9·8 metres in one second will be brought to rest when it has risen 4·9 metres in height. We are, therefore, entitled to say that a kilogramme, shot upwards with the velocity of 9.8 metres per second, has energy equal to 4.9 inasmuch as it can raise itself 4.9 metres in height.

" Let us next suppose that the velocity with which the kilogramme is shot upwards is that of 19·6 metres per second. It is known to all who have studied dynamics that the kilogramme will now mount not only twice, but four times as high as it did in the last instance—in other words, it will now mount 19·6 metres in height.

" Evidently, then, in accordance with our principles of measurement, the kilogramme has now four times as much energy as it had in the last instance, because it can raise itself four times as high, and therefore do four times as much work, and thus we see that the energy is increased four times by doubling the velocity.

" Had the initial velocity been three times that of the first instance, or 29·4 metres per second, it might in like manner be shown that the height attained would have been 44·1 metres, so that by tripling the velocity the energy is increased nine times."—*Conversation of Energy*, *p.* 18.

But the facts given are necessary deductions from the continual increment of gravitating force. The kilogramme when shot up with the velocity of 9·8 meters per second, will only rise to the height of 4·9 metres, because it is all the time retarded by successive increments of gravity, in quantity sufficient to carry it from a state of rest, to 9.8, in the same time; so that its average velocity upward, is the mean between 0 and 9·8 metres, to wit: 4·9 metres, and to that height it will ascend during that second: when shot up with the velocity of 19·6 metres, it will be retarded during the first second 9·8 metres, leaving its velocity at the end of the second, 9·8 metres and making the average velocity during the second the mean between the initial velocity 19·6 and that at the end of the second 9·8, to wit: 14·7 metres to which height it will ascend in the first second. The remaining velocity 9·8 metres will carry it up 4·9 metres as in the former instance, and the ascent made in the two seconds 14·7+4·9 metres=19·6 metres the distance ascended in two seconds. When shot up with three times the initial velocity, to wit: 29·4 metres, the retardation in the first second will be the same as before, 9·8 metres, the average velocity for that second the mean between 19·6 metres and 29·4 metres, to wit: 24·5 metres, and, consequently, the ascent the same, 24·5 metres; with a remaining velocity of 19·6 metres. In the second second, the retardation is the same, 9·8, the average velocity 14·7, the ascent 14·7, and the remaining velocity 9·8 metres. In the third second the retardation being as before 9·8 metres, the ascent for the second will be the mean between the initial velocity of the second, 9·8 metres and 0, to wit: 4·9 metres, and the whole ascent will consequently be 24·5 metres+14·7 metres +4·9 metres=44·1 metres.

§ 283. The result is, therefore, a necessary consequence of the character of the resistance overcome and in no sense a peculiar phase, aspect, or property, of motion or of force. Because gravity is constant and steady in its action, equal portions manifesting itself in equal times, equal amounts of upward velocity is overcome in equal times, and a simple arithmetical calculation based upon this gives us the supposed law of *vis viva*. That is, upon the observed fact that the height of the ascent is proportioned to the square of the velocity physicists entirely overlooking the true and exceedingly simple interpretation of the phenomenon, have built the theory of *vis viva*, and imagined it to be a great fact or law of nature.

§ 284. It will be observed that the true explanation of this phenomenon is that the ascending kilogramme has to meet and overcome the same gravitative tension per second whether the upward voyage be short or long, slow or swift. When moving upward with double speed the actual resistance per second will be the same, but the proportional resistance only one half as great. With twice the uniform velocity it would traverse twice the distance in the same time, but, added to this, is the other element that the reduction of velocity is relatively only half as great, and the two principles acting together give us distances proportioned to the squares of times of ascent, as above. So in the descent, the fact that the distance traversed is as the squares of the times is a direct and necessary result of uniform acceleration caused by uniform increments of gravitative tension.

It follows, therefore, that the kilogramme does not ascend four times as high in two seconds as in one because of any specific difference in the working character of force at the two rates of velocity, but because of the uniform increments of resistance which it is called upon to overcome.

Kinematics.

§ 285. Prof. Tate says: "Newton's Second Law is now required: *Change of motion is proportional to the moving force, and takes place in the direction of the straight line in which the force acts.*

"Mark here most carefully that this simple law (upon which the *Parallelogram of Forces* depends) holds for *all* kinds of force alike. There is no special law for gravitative force, and others for electric and magnetic forces. All are defined alike, without reference to their origin.

"Motion, as Newton has previously defined it, is here used as a technical scientific term for what we now call *momentum.* It is the product of the mass moving into the velocity with which it moves. Change of motion, therefore, is change of momentum or the product of the mass of the moving body into its change of velocity. Now, a change of velocity is itself a velocity, as we see by the science of mere motion—kinematics, the purely mathematical science of mixed space and time.

"Newton's words, however, imply more than this. Of course, the longer a given force acts the greater will be the change of momentum which it produces; so that, to compare forces, which is the essence of the process of measuring them, we must give them equal times to act, or, in scientific language, we must measure a force by the *rate* at which it produces change of momentum."—*Advances in Physical Science*, p. 351.

"Unit momentum is that of one pound of matter moving with a velocity of one foot per second. Unit force is that force which, acting for one second, produces in unit of mass a velocity of one foot per second. In each of these statements you may put an ounce or a ton instead of a pound, and an inch or a mile in place of a foot, and their relative value will not be altered. But, suppose we take a minute instead of a second as the unit of time: one foot per second is 60 feet per minute, so this change of the time unit increases sixty-fold the nominal value of the momentum considered. But, in the case of the force, our statement would stand thus:—What we formerly called unit of force is that which, acting for one-sixtieth only of our new unit of time produces in a mass of one pound sixty-fold the new unit of velocity. In other words, the number expressing the momentum is increased sixty-fold, while that representing the force is increased three thousand six hundred fold.

"In fact, whatever be the system of units you employ, if you increase in any proportion the unit of time, the measure of a momentum is increased in that proportion simply, while that of a force is increased in the duplicate ratio. The two things are, therefore, of quite dissimilar nature, and cannot lawfully be equated to one another under any circumstances whatever. The mathematician expresses this distinction at once by saying that momentum is the Time-Integral of Force, because Force is the rate of change of Momentum."—*Ibid*, 353.

All the bewilderment here is in the fact that Prof. Tait calls that *Force* which we have been discussing under the name of *Vis Viva*, and gives to it as an essential principle, that increased power of doing work which it possesses, simply by virtue of its continuous augmentation. When this augmentation is cut off at any point, as it may be by the Atwood Machine and many other contrivances, Tait's "Force," or *Vis Viva*, instantly becomes momentum. That is, when a body moving under the influence of a continuously accretive force has the accretion cut off at any point, it thence onwards moves under the influence of the single volume of force at such moment possessed, and the work it is capable of doing will be measured accordingly. But if the accretion is not cut off this measure of force is continually added to, and has its power of work increased, not only by such continuous addition but by the fact, elsewhere discussed, that a greater velocity can overcome a greater resistance in the same unit of time. All this is something to which Prof. Tait and other physicists have been blinded, first, by Newton's erroneous doctrine of Inertia, and next, by the assumed necessity of squaring the laws of Force and Motion with the hypothesis of Conservation.

Penetration.

§ 286. Another point made in favor of the theory is that a ball fired into a block of wood will penetrate proportionally to the square of the velocity, *nearly.* The reason of this is that in addition to possessing momentum proportional to simple velocity, its greater speed gives less time for the impartation of the moving energy to the fibres of the wood adjoining the path of penetration, and, consequently, a greater *percentum* of the force is utilized in cutting or breaking the wood fibres immediately in front of it. As is well known, a slow ball will rend a ship's side much more effectively than a swift one, because there is time for a much greater *percentum* of the energy to be communicated to the material composing the hull of the vessel. For the same reason, a slow bullet will shatter a window-pane whereas a swift one will only cut out a round hole in its passage.

Mr. Norton says: "If a given force generates a given motion a double force will generate double the velocity. It must not be supposed, that twice the velocity will actually be realized. Thus if an engine can propel a steamboat ten miles per hour, two engines of the same power will not double its speed, because the resistance of the water increases as the square of the velocity."—*Natural Philosophy*, p. 55.

§ 287. It will be readily seen that all this doctrine, of velocity, *vis viva*, and the measure of force, is dependent upon the definition of *work* as being force exerted through space, or motion in space, to the exclusion of mere pressure or tension, and this definition is in turn dependent upon the arbitrary distinction of kinetic energy or work on the one hand and force or pressure on the other. It assumes that the indices of work done are mass and distance traversed, and that the energy expended is always the equivalent of the product of these.

Momentum.

§ 288. Now were it true that the same expenditure would always carry the same mass over the same distance in the same time this view would be correct. But experience teaches us that this is not true; that, on the contrary, in every case, before we can ascertain whether equal expenditures of energy will have equal results as above, we must take into the calculation the amounts of resistance severally to be overcome. Therefore, the true test of any quantum of energy is the amount of resistance it will overcome in unit of time. If as much resistance is overcome in travelling one foot as one mile in a second, it is because as much energy is expended in doing it and the measure is really the same. Two teams with equal loads may travel side by side with the same speed, one on the shady side, with a good sleighing track, almost without expenditure of energy, the other on the sunny side where the snow is melted, tugging away almost to exhaustion. The scientists say the measures of work are the same. The practical, common-sense farmer says his team on the sunny side of the road is expending three or four times as much strength as the other, and is, therefore, doing that much more work. And he knows, too, that the muscular strength so exhausted will have to be resupplied by liberal allowances of hay and oats.

§ 289. One other view of this doctrine may be presented. If it were true that kinetic energy is as the square of velocity, then it should be true also that the energy initiating motion is as the square of the velocity; for if it should be that by simply doubling the initial force, the velocity would be doubled, and thereby the kinetic energy would be quadrupled—a ready means of creating power would be presented. For by doubling the velocity of a moving body its "striking force" against a second body is quadrupled, and if of the same size the other body would move with quadruple speed, and if it should impinge upon a third body of the same size the velocity would be increased to the fourth power, and so on, without limit. But we know from experience this is not true. Therefore the initial energy must be the same as the kinetic energy of the moving body, and both are the same as the velocity.

Prof. Stewart negatives the first part of this proposition: "It is not, however, equally easy to see that in order to produce *double* velocity in a mass, we must have a force twice as large as that which produces *unit* velocity in the same mass in the same time. But the truth of this statement will afterwards be perceived."—*El. Physics*, p. 14.

Again: "Let us, in the first place, suppose that the forces act in the same direction. For instance, imagine a piece of iron to fall by the action of gravity; at the end of one second it will have the velocity of 9·8 metres. Suppose, now, that at the same moment at which gravity began to act upon it, and to cause it to fall, it was acted upon by a magnet, so placed as to give it in one second a downward velocity of 9·8 metres. Then, owing to the joint effect of gravity and of the magnet, it will at the end of one second, according to this law of motion, have acquired a velocity of $9{\cdot}8+9{\cdot}8=19{\cdot}6$ metres per second, and have passed over the space of 9·8 metres instead of 4·9 metres, which it would have passed over through gravity alone.

"Hence we are able to extend our definition of force. We thus see that if a double force be applied to the same body, it will produce a double velocity in unit of time, a triple force a triple velocity and so on; in fact, a force may be measured by the velocity which it generates when applied for one second to a given body. Thus, suppose our unit of force is that which, when applied to unit of mass produces unit of velocity in unit of time, then a force represented by *two* will produce in the same mass a velocity equal to *two* in unit of time, and so on. So that in fact, regarding both mass and velocity, we see that the magnitude of a force is represented by the product of the mass into the velocity produced in it by the action of the force in unit of time. Suppose, for instance, that a force, acting during one second, produced in mass 3, a velocity 6, then it would be equal to 3x6, or 18, and so on. The product of the mass into the velocity is called the MOMENTUM, so that a force is represented by the momentum generated by it in a unit of time."—*Ib.*, 26.

Profs. Stewart and Tait, indirectly, state the same proposition: "As an illustration take a loaded cannon. Before firing, neither cannon nor ball had momentum. After firing the ball has a certain momentum, the cannon (in virtue of its recoil) an *equal* and opposite momentum. If we could exactly reverse the motions of the cannon and ball just as they separate, the impact between them would just reduce each to rest, and no momentum would be left." *Unseen Universe*, p. 106.

Again: "Now to our cannon again. Before firing there is no *vis viva* of either cannon or ball. After firing each has *vis viva*, but that of the ball is greater than that of the cannon in the proportion in which the cannon's mass exceeds that of the ball. And the system as a whole has *vis viva* though it has no momentum. If, as before, we could reverse the motions of cannon and ball, then, even when they impinged, the *vis viva* would *not* be lost. As will presently be seen, it would be employed in heating both the impinging bodies." *Ibid.*, 107.

That is to say, the cannon and ball have velocities in opposite directions inversely proportional to their respective masses, and if their motions could be reversed they would do equal amounts of work in bringing each other to rest. But, were the opposite contention true, the product of the cannon's mass into the square of its low velocity would be immensely less than the product of the ball's mass into the square of its high velocity, so that when reversed the ball would have immensely more energy and consequently be able to do immensely more work than simply to reduce the cannon to rest.

But Prof. Newcomb takes the opposite view: "The force required to impress a given velocity on a body falling through any distance is proportional to the square of the velocity, four times the force being required to give double the velocity, nine times to increase it threefold and so on. To give eight times the velocity would require sixty-four times the attracting mass." *Popular Astronomy*, p. 487.

Prof. Newcomb is right as regards the *orbital* motion of the planets, but that is an altogether different problem from the one under discussion, and, as will be shown hereafter, based on altogether different principles.

CHAPTER XV.

MEASURE OF ENERGY.

UNIT OF FORCE—TYNDALL—STEWART—FOOT POUND —TAIT—TWO ELEMENTS IN MOTION—OVERCOMING RESISTANCE—ILLUSORY STANDARD OF MEASURE.

Unit of Force.

§ 290. Stewart thus defines a "Unit of Force": "Let this be the force that will impart to unit of mass unit of velocity in unit of time, or, in other words, a force that if applied during a second to the mass of a gramme, will produce in it a velocity of one metre in a second."—*Elementary Physics*, *p*. 13.

Prof. Tyndall says: "Now the work done, or, as it is sometimes called, the mechanical effect,—as before explained, is proportional to the height." And "the absolute amount of work done depends wholly upon two things: first of all on the quantity of matter that is lifted; and, secondly on the height to which it is lifted." *Annual of Sci. Discovery*, 1865, *p*. 104. Prof. Stewart says: "From these examples we are entitled to draw the following rule: multiply the weight raised (in kilogrammes) by the vertical height (in metres) through which it is raised and the result will be the work done(in kilogrammetres)." *Cons, of Eng., p.* 16. Again: "If a kilogramme be raised one metre high against the force of gravity, we may call it one unit of work, and two kilogrammes raised one metre high or one kilogramme raised two metres high will represent two units and so on. We have therefore only to multiply the number of kilogrammes by the vertical height in metres to which they are raised, and the product will represent the work done against gravity." *Elementary Physics, p.* 101.

A Foot-Pound is thus defined: "The unit of energy or of work done; viz: one pound avoirdupois raised, or acting, through the distance of one foot." *Webster.* "The unit by which the *work done* by a force is estimated; thus (taking 1 lb. and 1 ft. as the units of weight and distance), if 1 lb. be raised through 1 ft., the *work done* is equal to 1 foot-pound; if 10 lbs. be raised 9 ft., the *work done* is 90 foot-pounds." *Manifold Cyclopœdia.*

Prof. Tait says: "The product of a force into the space through which it moves its point of application in its own direction is what we now call the amount of *work done* by the force." *Advances in Physical Science, p.* 35.

§ 291. Now, while it is not very clear whether these various definitions are intended to harmonize, nor indeed whether these different writers have the same notions regarding force measurement, they do seem to convey the prevalent idea that *time* is not an essential element therein. It is true that in the first extract above Prof. Stewart makes time an element of the calculation, but it is equally true that he is there speaking of accretive forces like gravity and not of single volumes of force. And all the other extracts ignore the time element altogether. This will more fully appear in another extract from a very lucid article on "Force" in the *Manifold Cyclopædia*: "In other words, if a pound of water fall to the ground through 772 ft. and be then suddenly arrested, its temperature will be raised one degree; and conversely, the heat that would raise the temperature of a pound of water one degree, would, if applied by a steam-engine or otherwise, raise 772 pounds one foot high."

The principle to be educed from these extracts, and which seems to be endorsed by physicists generally, is that the measure of force is obtained by taking the product of the mass moved into the spatial distance through which the motion transpires.

§ 292. And this proposition is supposed to be supported by the further theory that, although momentum is found by taking the product of mass into velocity; actual energy, the power of doing work, is measured by the product of mass into the square of velocity. But it has already been shown that this supposed phenomenon is not a property of force but a status or condition consequent upon the character of resistance.

Two Elements of Motion.

§ 293. It must be borne in mind that there may be two elements in motion. One simple translation in pure space where there is nothing to be overcome but the inertia of mass. Here the velocity is directly as the force, and inversely as the mass, and, therefore, the measure of force is the product of velocity into mass, and the lifting 772 pounds one foot in one minute, and one pound 772 feet in one minute, would be equivalent exertions of force.

The other element is *resistance overcome*, and whenever this is found, it has to be added to the translation element, and the expressions are necessarily different.

§ 294. Without resistance it would be twice as much work to lift one pound 1544 feet in one minute as to lift 772 pounds to the same height in the same time; twice as much work to lift 772 pounds one foot in thirty seconds as in one minute; twice as much work to lift 772 pounds two feet as one foot in one minute; but when motion is resisted, as it practically always is, none of these propositions are equivalents. Take Dr. Stewart's kilogramme for illustration. Twice the velocity lifts it 4 times as high. Why? Because the resistance of gravity being constant and continuous, the more rapid the path, the less gravity it has to overcome while pursuing it; or, in other words, it has the same amount of resistance to overcome in each successive second, and the fewer seconds it is occupied in its flight the less resistance it has to overcome, the more work it does in pure translation, and the less it does against gravity. Suppose the 772 pounds drawn up by horse power by means of a rope thrown over a pulley. Considered as a question of pure translation without any resisting force or motion, it would be twice as much work to lift the weight one foot in one minute as in two minutes; but when the horse is occupied two minutes in making a foot of distance he is resisted by just twice the gravitative force as when it is accomplished in one minute. If he lifts it two feet in one minute the resistance of gravity is no greater than for the one foot in the same time, but twice as much force is expended on the translation element. So the same amount of force is expended in the aspect of translation alone in lifting 772 pounds two feet in one minute, as in lifting 1544 pounds one foot in two minutes, but in the latter instance four times as much gravity has to be overcome. So it will appear that the so-called foot-pound measure, as understood and applied by scientists, is entirely unreliable and illusory and all the physical conclusions based upon it are probably fallacious.

CHAPTER XVI.

POTENTIAL ENERGY.

TYNDALL'S DEFINITION—STEWART AND TAIT'S—STEWART'S — GROVE'S — LEIBIG'S — SPENCER'S — STEWART'S KILOGRAMME—ANALYSIS OF STEWART'S KILOGRAMME—ANAYLSIS OF TYNDALL'S WEIGHT—THE THEORY ANALYZED—THE PRIMAL FORCE—SWINGING PENDULUM—WATCH-SPRING—CROSS-BOW—TUNING-FORK.

Tyndall's Illustration.

§ 295. It being apparent to all observation that motions do cease, and all visible results of energy do become dissipated, the first step in formulating the doctrine of Conservation was to find means of accounting for this phenomenon. The explanation of science is the theory of Potential Energy, otherwise called Energy of Position, which is thus stated and illustrated by various physicists :

§ 296. Prof. Tyndall says:

"I have here a lead weight attached to a string which passes over a pulley at the top of the room. We know that the earth and the weight are mutually attractive ; the weight now rests upon the earth, and exerts a certain pressure upon its surface. The weight and the earth here *touch each other;* their mutual attraction are as far as possible satisfied, and *motion*, by their mutual approach, is no longer possible. As far as the attraction of gravity is concerned, the possibility of producing motion ceases as soon as the two attracting bodies are actually in contact.

"I draw up this weight. It is now suspended at a height of sixteen feet above the floor; it is just as motionless as when it rested on the floor; but by introducing a space between the floor and it, I have changed the condition of the weight. By raising it I have conferred upon it a motion-producing power. There is now an action possible to it, which was not possible when it rested upon the earth; *it can fall*, and in its descent can turn a machine or perform other work. It has no energy as it hangs there, dead and motionless; but energy is possible to it, and we might fairly use the term *possible energy* to express this power of motion which the weight possesses, but which has not yet been exercised by falling; or we might call it potential energy; as some eminent men have already done. This potential energy is derived, in the case before us, from the pull of gravity, which pull, however, has not yet eventuated in motion. But I now let the string go; the weight falls, and reaches the earth's surface with a velocity of thirty-two feet per second. At every moment of its descent, it was pulled down by gravity, and its final moving force is the summation of the pulls. While in the act of falling, the energy of the weight is active. It may be called *actual* energy, in antithesis to *possible*; or it may be called *dynamic* energy, in antithesis to *potential*, or we might call the energy with which the weight descends *moving force*. Do not be inattentive to these points; we must be able promptly to distinguish between energy in *store* and energy *in action*."

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"Our weight started from a height of sixteen feet; let us fix our attention upon it after it has accomplished the first foot of its fall. The total pull, if I may use the term, to be expended upon it, has been thus diminished by the amount expended in passing through the first foot. At the height of fifteen feet it has one foot less of potential energy than it possessed at the height of sixteen feet, but at the height of fifteen feet it has got an equivalent amount of dynamic or actual energy, which, if reversed in direction, would raise it again to its primitive height. Hence, as potential energy disappears, dynamic energy comes into play. *Throughout the universe the sum of these two energies is constant.*

"It is as yet too early to refer to organic processes, but could we observe the molecular condition of my arm as I drew up that weight, it would be seen that in accomplishing this mechanical act an equivalent amount of some other form of motion was consumed. If the weight were raised by common heat, a portion of heat would disappear exactly equivalent to the work done. The weight is about one pound, and to raise it sixteen feet would consume as much heat as would raise the temperature of a cubic foot of air, about 1° F. Conversely, this quantity of heat would be generated by the falling of the weight from the height of sixteen feet. It is easy to see that, if the force of gravity were immensely greater than it is, an immensely greater amount of heat would have to be expended to raise the weight. The greater the attraction, the greater would be the amount of heat necessary to overcome it; but conversely, the greater would be the amount of heat which a falling body would then develope by its collision with the earth." —*Heat as a Mode of Motion, page* 152.

Stewart and Tait.

§ 297. Stewart and Tait say: "We have just now spoken about a cannon ball fired into the air against the force of gravity. Such a ball, as it mounts, will, each moment, lose part of its velocity, until it finally comes to a standstill, after which it will begin to descend. When it is just turning it is perfectly harmless, and if we were standing on the top of a cliff to which it had just reached, we might without danger catch it in our arms and lodge it on the cliff. Its energy has apparently disappeared. Let us, however, see whether this is really true or not. It was fired up at us, let us say, by a foe at the bottom of the cliff, and the thought occurs to us to drop it down upon him again, which we do with great success, for he is smashed to pieces by the ball.

"In truth, dynamics inform us that such a ball will again strike the ground with a velocity, and, therefore, with an energy precisely equal to that with which it was originally projected upwards. Now, when at the top of the cliff, if it had not the energy due to actual motion, it had nevertheless some sort of energy due to its elevated position, for it had obviously the power of doing work. A pond of still water, unless it can fall, *i. e.*, unless it has what is technically called a '*head*,' is of no use in driving a water-wheel. The head, or the power of descending, gives it a store of dormant energy, which becomes active as the water gradually descends. —*Unseen Universe*, p. 108.

"When work is done against gravity, as in lifting a mass from the ground, we have just seen that it is (as it were) stored up in the raised mass; we can recover it any time by letting the mass descend. Thus it is that we furnish a clock with motive power sufficient to keep it going for a week in spite of friction and other resistance, by simply winding up its weights.

"When work is done against molecular forces, we have a similar storing up, as, for instance, in drawing a bow or in winding up a watch."—*Ibid.*, p. 110.

Dr. Balfour Stewart.

§ 298. *In Conservation of Energy*, p. 23; Dr. Balfour Stewart says: "And now let us state that this same energy or power of doing work may nevertheless be possessed by a body absolutely at rest. It will be remembered (Art. 26) that in one case where a kilogramme was shot vertically upwards, we supposed it to be caught at the summit of its flight, and lodged on the top of a house. Here, then, it rests without motion, but yet not without the power of doing work, and hence not without energy. For we know very well that if we let it fall it will strike the ground with as much velocity, and, therefore, with as much energy, as it had when it was originally projected upwards. Or we may, if we choose, make use of its energy to assist us in driving in a pile, or utilize it in a multitude of ways.

"In its lofty position it is, therefore, not without energy, but this is of a quiet nature, and not due in the least to motion. To what, then, is it due? We reply, to the position which the kilogramme occupies at the top of the house. For, just as a body in motion is a very different thing (as regards energy) from a body at rest, so is a body at the top of a house a different thing from a body at the bottom."

Again, on page 27, he says: "We have thus endeavored to show that there is an energy of repose as well as a living energy, an energy of position as well as of motion; and now let us trace the changes which take place in a weight, shot vertically upwards, as it continues to rise. It starts with a certain amount of energy of motion, but as it ascends, this is by degrees changed into that of position, until, when it gets to the top of its flight, its energy is entirely due to position.

"Take an example, let us suppose that a Kilogramme is projected vertically upwards with the velocity of 19·6 metres in one second. According to the formula of Art. 28, it contains 19·6 units of energy due to its actual velocity.

"If we examine it at the end of one second, we shall find that it has risen 14·7 metres in height, and has now the velocity of 9·8. This velocity we know (Art. 26) denotes an amount of actual energy equal to 4·9, while the height reached corresponds to an energy of position equal to 14–7. The kilogramme has, therefore, at this moment a total energy of 19·6, of which 14·7 units are due to position, and 4·9 to actual motion.

"If we next examine it at the end of another second, we shall find that it has just been brought to rest, so that its energy of motion is *nil;* nevertheless, it has succeeded in raising itself 19·6 metres in height so that its energy of position is 19·6.

"There is, therefore, no disappearance of energy during the rise of the kilogramme, but merely a gradual change from one kind to another. It starts with actual energy, and this is gradually changed into that of position, but if at any stage of its ascent, we add together the actual energy, and that due to position, we shall find that this sum always remains the same.

"Precisely the reverse takes place when the kilogramme begins its descent. It starts on its downward journey with no energy of motion whatever, but with a certain amount of energy of position; as it falls, its energy of position becomes less, and its actual energy greater, the sum of the two remaining constant throughout, until, when it is about to strike the ground, its energy of position has been entirely changed into that of actual motion, and it now approaches the ground with the velocity, and, therefore, with the energy, which it had when it was originally projected upwards."

Dr. Stewart in the above quoted work, page 79, uses this illustration: "A pendulum, for instance, when at its lowest point, has only the energy of actual motion, in virtue of which it ascends a certain distance against the force of gravity. When, however, it has completed its ascent, its energy is then due to position, and not to actual motion; and so on, it continues to oscillate, alternately changing the nature of its energy."

Prof. Grove says, page 31: "To wind up a clock, a certain amount of force is expended by the arm;

this force is given back by the descent of the weight."

Prof. Liebig says, page 388: "The motion of a clock is produced by a weight or spring; but it is the power of the human arm applied to stretch the spring or elevate the weight, which is expended in the movement of the wheels and pendulum in twenty-four hours, or in eight or fourteen days."

Tuning-Fork.

§ 299. Mr. Spencer, (First Principles, pp. 269, 270) takes an illustration from the vibrations of a tuning-fork to sustain the proposition of the universal persistence of force, and attempts to explain it on principles similar to those given of the swinging of a chandelier. After showing how a prong pulled out of its perpendicular by the finger vibrates when released, he says:

"The force exerted by the finger in bending the prong cannot disappear. Under what form does it exist? It exists under the form of that cohesive tension which it has generated amongst the particles. This cohesive tension cannot exist without an equivalent result. What is its equivalent result? The momentum generated in the prong while being carried back to its state of rest. This momentum too—what becomes of it? It must either continue as momentum or produce some correlative force of equal amount. It cannot continue as momentum since change of place is produced by cohesion of the parts; and thus it gradually disappears by being transformed into tension among these parts. This is retransformed into the equivalent momentum; and so on continuously."

§ 300. Dr. Stewart's kilogramme illustration has been discussed and explained in another aspect and in a different connection. And now it remains for us to see whether it gives countenance to the theory in whose behalf it is here brought into court. Is it true that the projectile force enters into the moving body and becomes quiescent there, where it may happen to lodge for days, it may be, or centuries, as likely, but always ready to spring into life on any displacement?

Stewart's Kilogramme.

Let us notice what are the facts. Gravity acts upon it all the time, during the ascent, while resting on the cliff, and while falling; and while on its high position its weight or pressure in any particular time is just equal to what it would accumulate and transmit by impact in freely falling for the same length of time. Suppose a tower 400 feet high and two stones of equal weight resting on its edge. They all the time transmit equal amounts of pressure to the ground beneath. Now let one of them be pushed off, it will fall with accelerated velocity for five seconds when it will strike the earth. But in the same time the other will do just as much work, for the pressure which it will transmit in the five seconds will just equal the momentum acquired by the falling stone that is 32×5 multiplied by the weight of the stone. While resting on the tower the stones have no energy save that of gravity, which is momentarily transmitted as fast as received. While falling there is no exchange of different forms of energy, but simply a continuous reception of gravitating force driving it downward with accelerating velocity. The notion of an Energy of Position while remaining on the tower is a myth; the stone is simply in such a position that, if pushed off, the gravitating force which it is all the time receiving, will, instead of being passed downwards through the walls of the tower, as formerly, be accumulated until it reaches the ground, and then be imparted by impact.

This doctrine of two characters of Energy is necessary to the support of the theory of Conservation, and if this necessity had not existed it is not likely it would now be anywhere advocated. It is similar to the error of clothing Inertia with the characters of Force, and equally hurtful in its results.

The fact is, Energy means Force—as *weight* or *pressure* in bodies at rest, as momentum in moving bodies, just this and no more.

§ 301. But let the tangible facts in all this phenomena of Dr. Stewart's kilogramme be sifted out, and what do we find?

1. *Something* passes from the man's arm or other source of projectile force to the kilogramme, causing it to ascend.

2. The ascent is continually retarded until brought to on the cliff.

3. On the cliff the kilogramme rests without motion.

4. When dislodged it falls to the ground with continually accelerated velocity.

5. The time of descent is the same as that of ascent.

6. The velocity at the end of the fall is the same as that with which it commenced to rise.

7. The velocity in passing any point in the path is the same in the ascent as in the descent.

8. An unproved contention, granted for the present: On impact with the ground an amount of heat is developed precisely sufficient, if it could be all utilized in reversion, to again send the kilogramme up with the same velocity and to the same height.

Whence, and from these facts alone, say the physicists: "Therefore, the something which passes from the arm or other source of projection to the kilogramme, and which we denominate Energy or the Power of doing Work, persists all the way round not only in equivalence and quantity but in the essence of being as well. It is the same *something* in the drawn arm, in the rising kilogramme, in the resting kilogramme, in the falling kilogramme, and in the radiating heat."

§ 302. But supposing for the present that there is no other explanation of the phenomena, is it certain that there is anything here to hang a "Therefore" upon? Is it clear that the premises built up of the eight facts admitted above afford logical support for the conclusion? In other words, does the conclusion naturally and necessarily arise out of the consideration of these facts? If it does not it is illegitimate and fallacious—particularly so in the logic of science. And if there be other cognate facts which present other explanation it may turn out that the contention of the physicists is not only unproven but disproven.

§ 303. What other relevant facts, then, if any, can be marshaled in illustration of the phenomena? Gravity, by all experience and all authority, is something which never ceases to act upon the kilogramme, whether rising, resting or falling. Is it not surpassing strange that the attempt should be made to formulate a philosophy of the moving kilogramme, independent of that principle which every thinking mind knows and admits never relaxes its hold upon it? But so it is, and it remains that the facts concerning it be gathered and marshaled as we have done with the facts arrayed by the physicists:

1. Gravity is constantly acting upon the kilogramme with equal measure of tension in equal times, whether rising, resting, or falling.
2. Gravity generates in the kilogramme falling from rest, and of course starting with no velocity, in one second, a speed of 32 feet per second.
3. In the second second of the fall another 32 feet of velocity will be generated, and the like amount in every second until the ground is reached. So that, at the moment of impact, the velocity attained is found by taking the product of 32 feet by the number of seconds of the fall.
4. The tension on the rising kilogramme is precisely the same per second as on the falling kilogramme. These facts are universally admitted.
5. The tension on the rising kilogramme being

opposite to the upward movement, obstructs and retards it.

6. The tension being precisely the same per second as in the falling kilogramme, the retardation must be the same per second in the one case as the acceleration or increase of velocity in the other, that is, 32 feet per second.

7. Therefore, if the velocity per second at the moment it starts be divided by 32, the quotient will be the time of the ascent in seconds.

8. The distance of the fall in feet is found by taking the product of one-half the velocity generated per second by the square of the time of the fall in seconds: $32\text{-}2\times 1^2 = 16$ feet the fall in one second; $32\text{-}2\times 2^2 = 64$ feet fall in two seconds; $32\text{-}2\times 3^2 = 144$ feet fall in 3 seconds, and so on. The reason of this rule has been illustrated elsewhere, § 235.

9. The distance of the ascent and descent being over the same path and between the same points must necessarily be the same.

10. The ascent is commenced with a certain velocity which is uniformly diminished to zero by successive retarding decrements of gravity at the rate of 32 feet per second.

11. The descent is commenced at zero, and uniformly accelerated over the same distance by successive increments of gravitating tension at the same rate of 32 feet per second.

12. In going in opposite directions the same distance over the same path, velocity is in one case built up from zero by successive increments of 32 feet per second and the other way pared down to zero by decrements of like amount. It follows from this that: 1. The times of ascent and descent must be equal; 2. The final velocity of the descent must be the same as the initial velocity of the ascent, and 3. The velocity at any point in the path must be the same in both directions.

13. A necessary corollary to this is that the retardation of the ascending kilogramme, like the

acceleration of the falling kilogramme, is caused by gravity.

14. A further necessary conclusion is that the Equivalence of times, velocities, and momenta, which has seemingly been the Circe of physicists, arises directly from the uniformity of gravitative tension.

§ 304. To repeat: instead of some mysterious process of the transformation of actual energy into potential energy under some mysterious law, it is the retardation of gravity acting under its known laws, which exhausts the upward motion of the kilogramme. Instead of its resting quietly on the cliff, *because* its actual energy has metamorphosed into energy of position, its quietude is by reason of the total overcoming of its ascending motion by gravity. Instead of its falling, when displaced by reason of the rejuvenation of the original upward energy which has been sleeping for long in potential form on the cliff, it is drawn or driven downward by continuous gravitative tension.

Here, then, is full and sufficient reason for the whole phenomena in principles, either universally admitted, or in inferences, not only naturally, but necessarily drawn therefrom.

Tyndall's Raised Weight.

§ 305. And all this Prof. Tyndall, in the extract quoted, directly or indirectly, admits. He says that while the weight rests on the earth, gravity presses it down, that gravity resists its rise, and when the string is loosed gravity pulls it down. Now, *what gravity does do, something else does not do.* When he says gravity pulls the weight down he directly and positively excludes and negatives the idea that what pulls it down is the metamorphosed muscular energy of his arm, which was expended in pulling it up. And, right here is the key to the whole doctrine of Conservation. The other physicists, entirely ignoring gravity, say that the identical muscular energy of

Prof. Tyndall's arm which pulled the leaden weight up from floor to ceiling was first transformed into Potential Energy, and, as such, rested quietly in the weight till its fall commenced when the same identical energy was retransformed into actual energy as the fall transpired, and upon impact with the floor was all metamorphosed into heat. And just what they say about it is necessary to the integrity of the doctrine of Conservation. If they are not actually and absolutely correct as to the veritable identity in essence throughout the circle, of the force which left Prof. Tyndall's arm in the act of lifting the weight, then Conservation is gone and forever. Prof. Tyndall says they are not correct, and he says according to the reason and logic of the matter.

§ 306. It is true, however, that Prof. Tyndall is not logical throughout his illustration. If gravity pulls the weight down it is not logical for him to say he has "conferred a motion-producing power" on the weight. He has done no such thing. The weight has no power of itself. The *gravity* in it is the *power*, and that Prof. Tyndall did not bestow. What he did do was to change the position and supports of the weight so the pressure of gravity could more readily pass into kinetic motion. Unless he uses energy as a synonym for gravity, it is not logical to say the "energy of the weight is action," for it is the gravity in the weight which is active.

After admitting that gravity pulls, it is not logical to talk any more about the two kinds of energy, for the admission carries with it the whole case. Gravity is the only cause, thing, or force concerned in the pulling down before he lets go the string, or during the fall after he lets go; there is nothing there but the weight or gravity; and gravity is not of two kinds, but one only.

§ 307. He is not logical when he speaks, as other scientists do, of energy being *stored* in the weight. There is nothing *stored* in it, nothing in it at the ceiling which was not in it on the floor. Indeed, instead of energy, or anything else being stored in it, two measures of energy or force have been dissipated and passed out of all human recognition or computation. The energy which passed from Prof. Tyndall's arm into the weight is gone ; he nor any other other man can trace or track it. So with the gravitating energy received by the weight during the ascent; it is gone, and none can tell what has become of it. And right here is where Conservation failed so signally and absolutely that the myth of Potential Energy was invented to save it from utter extinction.

§ 308. But granting his premises, let us see how far Prof. Tyndall can logically and consistently go. A certain amount of heat-force is expended in lifting the weight sixteen feet against gravity. A certain amount of gravity is exerted in bringing it to the floor again which is, by the impact converted into an equivalent amount of heat to that expended in the ascent. That is to say the gravity exerted, and all transformed into heat by the impact, is the exact equivalent in amount to a former quantity of heat expended against a prior measure of gravity in the ascent; a mere quantitative equivalence, nothing more. Anything further is absolutely gratuitous; as Judge Stallo says of the current scientific notion about Inertia, it is "spurious."

As already shown, the one great undoubted fact is the equivalence of times, velocities, and momenta in the two flights of the weight, and that is a necessary consequence of the uniform tension of gravity. And *equivalence* being fully accounted for by gravity cannot be logically used as an argument in favor of a supposed different and contradictory principle.

Equivalence of Position and Force.

§ 309, And we may now take time to note how inadequate is this theory of the physicists at the best. It supposes a *something* undefined and undefinable existing now in one form and now in another ; now tangibly, visibly, and impressively active, and now dead beyond all tracing, recognition, or identification ; now a subject of quantitative admeasurement, and now as unweighable and unmeasurable as zero itself ; in fact, passing at will from entity to nonentity, from something to nothing and back again. It makes distance in space the power to do work, and not only the equivalent to but the *same in essence* as the original muscular energy. It says that in the ascent as the motion slackens, the weight all the time receding from earth, has at every point precisely as much energy of position as it has lost of actual energy : that is, at any point if the upward motion were stopped it would fall, striking the ground with the exact equivalence of velocity to that which it lost in the ascent ; and not only so, but that the recovered actual energy is the *same existence* as the actual energy with which it started up, which was gradually changed into energy of position in the ascent, and as gradually retransformed into actual energy during the descent. When resting upon the cliff the whole of ascending actual energy has been metamorphosed into energy of position, and now, if by any chance it is shoved off, in the fall the energy of position is all remetamorphosed into an equivalent amount of actual energy again : and not only so, but into *identically the same actual energy*, the *same power of doing work*, the *same active attribute of something*, *some existence.* It makes the height of the fall the power of doing work—it says so much fall is equal to so much actual energy, and not only equal to it but *identically the same* as so much actual energy ; and not only the *same as*, but the *metamorphosis of* so much actual energy. It makes actual energy and distance above the ground, not only quantitative equivalents, but different forms or modes of the *same something*, *the same existence.*

§ 310. And now let us, if possible, get a little closer to the shadowy notion which physicists here seem trying, as it were, to fix and photograph.

Gravity, as admitted, acts upon the resting weight the same as when falling, but why does it not fall? Because it is supported. The cliff is made up of layers of rock whose particles are held together by forces known as molecular forces, and for that reason, the layers of the cliff refuse to get out of the way. That is to say, the pressure of the kilogramme on the cliff by reason of the constant tension of gravity, is constantly resisted by the molecular forces in the rocks composing the cliff, and for that reason, and none other, the kilogramme does not fall. But when by the intercession of any other force, of whatever kind or however trivial, the weight is pushed over the edge of the cliff so as no longer to be supported thereby, the pressure or gravitative tension, not being now resisted by the molecular forces of the cliff formations, begins its fall at once. Remember now that the power of doing work is defined as the power of producing change or causing motion in matter, and it is seen at once that the weight resting on the cliff, does not, in fact, possess any power of doing work *because it is supported.* The power, if such it may be called, comes into play only when the support is withdrawn. And it makes no difference how the withdrawal is made, whether by pushing the kilogramme off the cliff, or by slipping the cliff from under it. So that really, what is meant by this power of doing work is that the obstruction to gravitative tension or pressure is removed.

§ 311. But suppose the weight was two seconds in its assent. Then it started up with 64 feet velocity and the cliff is 64 feet high. Now suppose that while the weight is resting on the cliff a shaft is sunk at its base 192 feet deep and that the weight continues its descent to its bottom. The whole time will be four seconds, and the final velocity 128 feet per second. Now, by the theory, the *quantum* of potential energy in the resting weight was just equal to the initial actual velocity in the ascending weight, and capable of doing precisely the same amount of work, that is, of carrying the weight over the same path with reversed velocity, and is in fact, the SAME energy transformed. Therefore, when the weight reaches the mouth of the shaft, this exact equivalence of downward work has been performed—all the potential energy sleeping on the top of the cliff has been reconverted into actual energy. It follows that the weight *should* fall the balance of the way with the uniform velocity of 64 feet. But we find that it does not behave in that way. On the contrary, the acceleration is just as great after as before, that is, the actual energy grows up in the weight just as fast after it passes the entrance to the shaft as before. We understand by the theory that this actual energy reacquired before the entrance is but the metamorphosed potential energy, but as at that point the metamorphosis is all complete, whence comes that which is acquired after entering the shaft? The theory is silent here, it cannot answer. Is it not clear that the *cause* of the whole descent, both before and after entering the shaft is the same: *the pressure or tension of gravity*, nothing more and nothing less? and that it has no causal relation whatever with the original energy of the ascent? that the whole notion of potential energy in such case is a fiction, a figment of imagination?

§ 312. Leibnitz says: "a body must first be raised up before it can fall." But take a piece of the top formation of the cliff which has never been any lower down to be raised up—will it not fall just as readily and just as rapidly, developing just as much actual energy in the same time and through the same distance of fall as the stone which was thrown upward into the same position? If so, whence comes the actual energy of its fall? What is it a metamorphosis of? Is it not again clear that there is nothing but the pressure of gravity concerned with it?

Equivalence of Distance and Gravity.

§ 313. By some the theory is greatly expanded. It is said that originally the matter of our solar system existed in a greatly attenuated form of superheated gas, or perhaps ether, in which it possessed vast potential power by reason of its subjection to contractile forces; that, as it contracted, this potential energy was converted into actual energy, which, in the body of the sun, was transformed into heat. Now, mark the supposed course of events. In its diffused state it possessed the potential energy of spatial distance, as well as the actual exhaustive energy of heat, and the property or force of gravity. By the exercise of the latter it was drawn towards a common centre, while the heat was continually radiated off into space beyond any human following, and so far as we know, lost to the universe.

Prof. Merriman says: "Let us start, then, with that condition of things which it is now very generally conceded must once have existed—the diffusion of matter in a nebulous form throughout all space. Calculations easily made show that the nebulæ must have been of extreme tenuity—such that the few grains taken up on the point of a knife-blade must have been expanded to fill several cubic miles. A heat so powerful—for we know of no other force which could thus hold apart the atoms of matter—would doubtless be sufficient to resolve every known substance into its simplest elementary constituents, perhaps into a very few primordial elements; for chemists are far from being satisfied that they have arrived at the ultimate forms of matter in this list of sixty-five elements. But, however this may be, we know that the atoms, whatever they were, must have been held so far apart that no combination could possibly have existed."—*Pop. Sci. M.* April, 1877, p. 702.

While the two processes of gravitative contraction and radiation were going on, modern physicists say there was still another principle developing, that energy of position was transforming into actual energy, that is to say, that spatial distance was being converted into moving, molar, or kinetic force driving the atoms towards each other or towards a common centre. But this is exactly the office and work already assigned to Gravity, and it comes to this, that either Gravity and actual energy are the same thing, or else the latter is a useless superfluity, "a fifth wheel in the wagon" of creation. If the former hypothesis be accepted, then it follows that spatial distance metamorphoses into gravity, that the distance apart in space of any two atoms or points is converted by some unexplained process into the great sun-making and world-making force, Gravity. And this vague hypothesis is assumed and pressed by physicists as a fact, because something of the kind is imperatively needed to support the tottering theory of Conservation, which has no other possible facts for its foundation than certain numerical equivalents, as ascertained by measurements based on illusive principles, and with some of the factors ignored and left out.

§ 314. But on this hypothesis, by continuing to either ignore Gravity altogether, or saying it is the same thing as actual energy, physicists are enabled to say that the topmost rock of the cliff is a little remaining piece of the original potential energy of *Spatial Distance* from the centre of earth, which has never yet been reduced to actual energy, but which is abiding its time with quiet patience until, by some casual force, it shall be pushed over the edge when it will immediately, and for the first time in all the eternities past, change itself, or be changed by some mysterious power, law, or process, into actual, moving energy, in the FORM and under the *name* of Gravity until striking the ground, when it will again be converted, but this time into heat. So that distance from the ground, say the measure of 64 feet, or 112 feet, or 400 feet, or whatever else may be the height of the precipice, Gravity, and the heat resulting upon impact with the ground, are all manifestations of the *same existence*, forms or modes of the same entity, equivalent, not only numerically, but in *very essence.*

§ 315. But let us go back to Prof. Merriman's world-making.

In condensing, this energy of position, this separation in space, is gradually converted into actual energy of motion, by or through which the original material becomes continually more dense, until at some point, the condensation being arrested, the whole energy is turned into heat. We have then the three forms of energy, the same precisely in quantitative admeasurement and essence throughout: first, relative position in space or distance apart; second, the actual energy of motion towards condensation centres; and, third, heat. Distance, or rather separation in space, is, therefore, the first and original form of energy, the primordial cause of all other energy, and of all forms of existence. Inches and feet, miles and leagues it may be, have been the primal modes of causation, these changed into motion, and this into heat, heat back into motion and motion into inches or feet, and so on, everlastingly. Out of feet and inches the universe has been built up, into feet and inches it is continually shading out, and then reappearing. At all this the unlearned may smile, but it is science, as taught by advanced thinkers of the age. And so the scientist says, that the boulder in original place on the cliff simply retains 64 feet of its original potential energy, which it is ready to expend, whenever forced from its long resting-place over the edge of the cliff, and in that instance, at least, we can have the opportunity of observing a wonderful phenomenon—the first action and first conversion of a piece of the original energy with which creation was endowed! All else has changed millions upon millions of times, it may be, but this little piece of energy is primal. But, more wonderful still is it that this Universe, seemingly so full of Gravitation, has been wholly constructed without even the use of a particle of it! or, rather that what we call Gravity is but a mode of feet and inches, but a form of distance!

Pendulum.

§ 316. The same principles apply in the illustrations of the pendulum and chandelier. Mr. Spencer makes the original push given to the chandelier, alternate as it swings, from actual to potential energy; as it rises on one side, the actual, or living energy passing into unreal, dead or silent energy; and the converse as it falls back towards the lowest point of oscillation; and so on from one side to the other until stopped by friction and the resistance of the atmosphere, thus all the time ignoring Gravity, while, as a matter of fact, the adaptation of the pendulum, which swings on the same principle, to measuring time, rests on the conceded fact that it falls by the influence of Gravity alone from the highest to the lowest point of the arc of motion. Gravity brings it down on the one side, and the momentum acquired in the descent carries it up on the other, until stopped by the retardation of the same principle, when it turns and passes back over the same arc under the same influences, and so on, indefinitely. Thus the gravitative force which brings it down on one side is resisted by an equal measure of the same force on the other, and the two portions of force mutually dissipate each other. M. Arago says: "When the pendulum deviates from the vertical, the action of gravity brings it back," not the metamorphosed push of the finger, but *Gravity.*

Watch-Spring.

§ 317. Dr. Stewart says: "In like manner a watch wound up is in a position of advantage, with respect to the elastic force of the mainspring; and, as the wheels of the watch move this is gradually converted into energy of motion." That is, the muscular energy of the fingers expended in the winding is only stored in the spring in a latent form, and its gradual reconversion into active force causes the spring to unwind and the hands and wheels of the watch to move.

But, here again, it must be observed that one of nature's potent forces is overlooked. It is admitted by all, that in the winding the muscular force is resisted by, and has to overcome the tension or elasticity of the spring dependent on its molecular forces, called cohesion. But the moment the watch is wound up this elastic force is forgotten and discredited. For all the hours that the watch may run, they say it is by reason of the muscular force of the fingers first converted into potential force, and then back into active force, first into *nothing tangible*, *traceable*, *cognizable* or *imaginable*, and then back into actual living force, setting aside and substituting itself for the molecular energies of the spring. And this process is repeated every time the watch is wound up and run down. Elasticity is treated as of no account in the dynamics of nature; just as Gravity is ignored, and its office and work perverted and subverted in the examples already considered, so are Elasticity and Cohesion ignored here, and their work assigned to a different and imaginary factor. And all this is done, as in the other case, simply to sustain Conservation, because, otherwise that grand and beautiful theory will have to fall, as have fallen many another grand and beautiful fancy of the human brain.

The Cross-Bow.

§ 318. In the cross-bow, the muscular energy of the arm is exerted in drawing the string, and thus bending the bow, but this muscular energy is not converted into potential energy, and thus back into actual energy to speed the arrow. If it were, the longer the bow might be held in tension by means of the string, the more muscular force would be transformed into positional energy, to be reconverted into kinetic force the instant the string should be loosed, and, as a consequence, the longer the tension the harder the bolt. But such is not the case. The arrow will fly with no greater velocity, nor strike the target with any greater momentum at the end of a minute's constraint than at the end of a second's.

The true explanation is this: The muscular force, by pulling on the string, antagonizes the molecular forces in the bow, equal measures of both being thereby dissipated and lost. When the string is let slip the ends of the bow are carried back by the elastic forces generating kinetic force in them, which kinetic force is communicated to the string, and through the string to the arrow. So the arrow is not driven forward by metamorphosed muscular force, but by the elastic forces in the bow.

When the bend of the bow produced by muscular energy is secured by the bow-string, the latter evidently fills the place and office of the hands, with this difference only, that the hands would weary and fatigue, while the string does not. As the muscular energy of the hands antagonized and neutralized the molecular forces of the bow, so, evidently, do the molecular forces of the cord; and, as in the former struggle, the molecular forces of the bow are overcome and balanced, so must they be in this. So, also, as the respective molecular forces of the bow and string continuously neutralize each other, must they each be continuously received.

Tuning-Fork.

§ 319. And in the tuning-fork did muscular energy take the form of molecular tension, and as such, store itself up among the particles of the prong, it would follow that the longer the prong was bent by the finger, the greater would be this tension, and the harder the pull; for, evidently, the muscular energy is continually expended as in the instance of bending the bow; because, that after a time, the finger becomes fatigued. But this is not the case, for the rebound of the prong will be as great at the end of a second as of an hour.

The truth is, that when the prong is drawn back, there is an antagonism between the cohesion of its particles and the muscular energy of the finger, each resisting, balancing, and neutralizing the other; —and this continues so long as the strain continues. When the finger is removed, the molecular forces in the prong, continuing to pull as before, are converted into molar force sufficient to carry the prong, not only to the perpendicular, but as far beyond it against the tension of cohesion on that side, until it is exhausted by such resistance. But at this instant, the pull of cohesion on that side is, in its turn, converted into molar force, in quantity sufficient to carry the prong back to the original point, where, it is, in turn, exhausted by the pull of cohesion on this side, which is, in turn, converted into molar force; and thus the prong vibrates from side to side, cohesion being continually converted into molar force, and, in that form, continually resisted and exhausted by cohesion. Evidently, there must be a continuous supply of cohesive force, to take the place of that converted into molar force, as well as that neutralized in resisting it. All vibratory or undulatory action is explainable upon similar principles.

§ 320. The conversion of molecular into molar force in these instances is on the principle elsewhere elucidated of the continual effort of pressure force to pass into kinetic or moving force; and the continual growing up of molecular force to supply that exhausted or passed off in the struggle is an analogue to the continual re-supply of gravities and pressure-force elsewhere insisted upon. Now, all this may be only theory, but it has this basis of fact to build upon; force is continually given out, passed off, dissipated, exhausted, and yet the store is never diminished; and this further fact, that the behavior, the dissipation, the impartation, is just like that of muscular force, or steam force, where we know from observation and experiment there is a supplying of the waste.

§ 321. It may be thought that needless particularity has been devoted to a proposition stamped with suicidal absurdity on its very face, but it must be remembered that Potential Energy is the very keystone of Conservation, and that Conservation is the universal philosophy now moulding every form of thought, theory, and faith. The validity or invalidity of Conservation is to every form of belief the most momentous question that can possibly be propounded, for it holds them all in its grasp; but Conservation cannot be valid, unless the doctrine of Potential Energy be absolutely true.

CHAPTER XVII.

PRESSURE.

IN LIQUIDS—PROF. SILLIMAN—DESCHANEL—PASCAL—GASEOUS PRESSURE—DISSIPATION OF PRESSURE-FORCE.

In Liquids.

§ 322. The principles of pressure are exemplified with peculiar significance in liquids and gases. Concerning the pressure of liquids the following extracts are taken from Prof. Silliman's Natural Philosophy: "Liquids, owing to the slight cohesive attraction among their particles, possess no definite form, but adapt themselves to the shape of the containing vessel. This is a necessary consequence of the perfect freedom of motion among the particles of a liquid. Liquids vary very much, however in the degree of their fluidity, as between thin mobile liquids, like alcohol, or water, and thick, *viscous* bodies, like oils and tar. In viscous bodies the imperfect fluidity is a consequence of the only partial ascendency of the repulsive force, leaving a still notable amount of cohesion among the particles.

Heat serves to increase the repulsive force, and so converts viscous into thin liquids." Page 148.

"*Liquids transmit in all directions, and with the same intensity, the pressure exerted on any point of their mass.*

"This important theorem was first clearly announced by B. Pascal." *Ibid*, 151.

"The entire pressure sustained by any surface is proportional to its area, 'and thus,' in his *Treatise on the Equilibrium of Fluids*, 'it appears that a vessel full of water is a new principle in mechanics, and a new machine which will multiply force to any degree we choose.'" *Ibid*, 152.

"*The pressure exerted by a liquid on the horizontal base of a containing vessel, is*, 1*st*, *independent of the shape of the vessel*; 2*d*, *is equal to the weight of a column of this liquid, whose base is that of the vessel, and whose weight equals the depth of the liquid.*" *Ibid*, 153.

"Having shown that pressure in liquids is exerted from above downwards, it must follow from the law of equality of pressure, that a corresponding force is exerted from below upwards. * * * * *The upward pressure, in any vessel, is equal to the weight of a column of liquid, having the same base as the cylinder, A, and whose height equals the depth of the section below the surface of the liquid.*

"*The pressure of a liquid on any portion of a lateral wall, is equal to the weight of a column of liquid which has for its base this portion of the wall, and for its height the vertical distance from its centre of gravity to the surface of the liquid.*" *Ibid*, 154.

"Pascal made a striking experiment at Rouen, in 1647, to illustrate the enormous pressure exerted by a lofty column of water contained in a small tube. A strong cask filled with water, was fitted with a small tube about forty feet high. When this tube was filled with water, the effect of the pressure transmitted to all parts of the cask was sufficient to burst the vessel." *Ibid*, 156.

"The total pressure exercised on the bottom and sides of a vessel is much greater than the weight of the liquid contained in the vessel. In the case of a cubical vessel, the pressure exerted on the bottom is equal to the whole weight of the liquid, the pressure exerted on each side being equal to half the weight of the liquid, on the four sides it is equal to twice its weight, consequently, *in a cubical vessel the entire pressure exerted on the bottom and sides is equal to three times the weight of the contained liquid.*" *Ibid*, 157.

§ 323. All this is the result of the continual upgrowing of gravity in the liquid, its constant transmission downwards through the sub-cumbent particles of the body, and the mobility of the molecules, modified by the principle of virtual velocities. If at any moment there could cease to be a new reception of gravitative force the whole pressure would cease, but as this force passes downwards it tends to give kinetic force to every particle in its path, and on account of the want of cohesion amongst them they slide upon each other in every direction with the consequent result that the tendency to kinetic motion, and with it the pressure, is propagated in every direction. Because each layer of the liquid not only transmits its own gravitative pressure, but is the medium for the pressure of all above it, the pressure at every point is as the perpendicular depth from the surface. And hence arises a remarkable paradox: that the pressure on the bottom of a vessel containing liquid may be much greater than the whole weight of the full vessel, for the whole weight of the full vessel can only be according to its mass, *i.e.*, amount of matter, while, as stated by Prof. Silliman, the pressure of the liquid on the bottom is as the product of the surface of the bottom by the perpendicular depth from the surface of the liquid.

So the lateral pressure not being conducted downwards contributes nothing to the weight.

§ 324. And, of course, the upward pressure caused by a column of liquid in an inserted tube cannot add to the pressure on the bottom, and what again seems paradoxical, is that, though it does press upward, this pressure does not in the least lighten the weight of the full vessel.

§ 325. It follows that gravitative pressure downwards is not affected by lateral or upward pressure, and this on the principle of virtual velocities. The struggle of the gravitative force to pass into kinetic motion all the time goes on, as we have seen, downwards, laterally, and under certain circumstances, upward, with energies varying according to principles just discussed; and, if at any point, the pressure is sufficient to overcome the resistance, kinetic motion is set up and the pressure is relieved all around to that extent.

§ 326. Now that we may see a little more clearly why it is that all the downward pressure on the bottom of the vessel is not manifested in the weight of the full vessel, let us try an experiment. Place your hand upon the side of a full tank of water—you feel no pressure at all, although you know the water on the inside is exerting a mighty pressure against the wall opposite to your hand, and that, if not sufficiently secured at that point, it is liable to burst and hurl you away. Why do you not feel the pressure against your hand? Because the molecular cohesion of the walls of the vessel resist the outward pressure of the liquid, and,so long as equal to the duty, refuse to let it pass through or become manifest on the outside. So the cohesion of the bottom wall of the vessel resists the downward pressure and refuses to let all that portion due to virtual velocity, that is, all in excess of the weight of the liquid, pass downward through it.

§ 327. Take two vessels of same weight, capacity, and area of base, but one much taller than the other. Fill them with liquid and they will balance on the scales the same as when empty. Suspend them both and place your hands on the bottom of each ; you will feel no pressure against your hand from either. Yet you know from the principles already discussed that the pressure is much greater on the bottom of the tall vessel than on that of the low one. Why do you not feel it so? Because the cohesion of the particles in the bottom walls resists and refuses to give way before the pressure. Yet we know it is true that if the walls of the two vessels are of the same strength, the resistance of the bottom wall of the tall vessel is much more nearly overcome than that of the other, and a much less additional pressure will rupture it.

§ 328. An additional observation seems pertinent. Any pressure applied to the top or sides of a body of liquid will be propagated and transmitted in the same manner and on the same principles with the gravitative pressure. If the upper surface of a vessel of water is one square inch and a pressure of ten pounds be applied there by weight, or otherwise, it will exert the same amount of pressure on every square inch of interior surface, though there will be but simply the ten pounds added to the whole weight of the vessel of liquid. Upon this principle depends the utility of the hydrostatic or hydraulic press. And it matters not what may be the character of the added pressure, whether of a weight, or by the hand, or a steel spring, or a rubber cord, or of steam power. Whatever it may be it will be added to the gravitative pressure of the liquid, and, for the time, the two pressures will act together as one.

Deschanel says: "*A fluid in a closed vessel perfectly transmits through its whole substance whatever pressure we apply to any part.* The changes in *amount* of pressure will be equal for all equal areas. For unequal areas they will be proportional to the areas." *Natural Philosophy*, p. 86.

And he quotes from Pascal: "If a vessel full of water, closed on all sides, has two openings, one a hundred times as large as the other, and if each be supplied with a piston which fits exactly, a man pushing the small piston will exert a force which will equilibrate that of a hundred men pushing the piston which is a hundred times as large, and will overcome that of ninety-nine. And whatever may be the proportion of the openings, if the forces applied to the pistons are to each other as the openings, they will be in equilibrium."—*Ibid.* This is on the principle of virtual velocities, where time and space become factors, and the smaller piston moves over a hundred times the distance in the same time, that is with a hundred times the velocity of the other, whenever there is excess of pressure to produce any motion at all.

§ 329. Another important phenomenon of hydrostatic pressure is thus set forth by Deschanel: "When a system of forces is in equilibrium, the removal of one of them destroys the equilibrium, and causes the resultant of the system to be a force equal and opposite to the force removed. Accordingly, if we remove an element of one side of the containing vessel, leaving a hole through which the liquid can flow out, the remaining pressure against this side will be insufficient to preserve equilibrium, and there will be an excess of pressure in the opposite direction.

"This conclusion can be directly verified by experiment. A tall floating vessel of water is fitted with a horizontal discharge-pipe on one side near its base. The vessel is to be filled with water, and the discharge-pipe opened while the vessel is at rest. As the water flows out, the vessel will be observed to acquire a velocity, at first very slow, but continually increasing, in the opposite direction to that of the issuing stream." *Natural Philosophy*, p. 92.

§ 330. This phenomenon is just as if one with a rod passing water-tight through one side of the vessel pushed against the inner surface of the opposite side with an intensity just equal to the gravitative pressure on an area of surface of the same size as that of the opening, or if he pushed against the outer surface on the side of the opening with an equal intensity. As Prof. Deschanel very well puts it, the cause of the phenomenon is the excess of gravitative pressure in one direction by reason of the destruction of interior surface in the other. And this continual opposite pressure producing accelerated motion is a very beautiful illustration of the continuous action of gravity by which accelerated velocity is produced in falling bodies. And if the vessel could float on a frictionless fluid the rate of the acceleration would be the same.

Gaseous Pressure.

§ 331. This prepares us for the discussion of the behavior of gaseous bodies where the same principles apply to a certain extent, modified, however, by two important considerations, the quality of elasticity in gases and the intimate and obscure relations of heat and its action towards the same.

Prof. Deschanel says: "Gaseous bodies possess a number of properties in common with liquids: like them, they transmit pressures entire and in all directions, according to the principle of Pascal; but they differ essentially from liquids in the permanent repulsive force exerted between their molecules in virtue of which a mass of gas always tends to expand."—*Nat. Phi.*, p. 137.

"How large a vessel may be, it can always be filled by *any quantity whatever* of a gas, which will always exert pressure against the sides."—*Ibid.*

§ 332. Suppose a volume of gas filling a cylinder holding one gallon and pressing with such force that a vertical ten pound piston will just hold it down and observe the behavior of all the forces concerned. It may be noticed in the first place that the gravitative pressure of the piston passes through the gas, the bottom of the cylinder and any platform it may rest upon, and on into the earth towards its centre, just as it would through any other character of support, and that this pressure is continuous as is always the case with gravity. In the next place it may be observed that the gas presses against the sides of the cylinder and also against the end of the piston with precisely the same intensity that the piston presses upon it and that this pressure is also continuous.

§ 333. And now the illustration may be varied somewhat. Instead of a ten-pound piston a thin plate weighing but an ounce may be used with an arrangement holding it down by a steel spring or rubber band, adjusted to the cylinder. In this case the pressure on the gas, as also the pressure of the gas on the sides and bottom of the cylinder and on the end of the piston, will be precisely the same and equally continuous. But it will not be transmitted through the supports towards earth's centre, as was the gravitative force. But if there be a like pressure exerted on the plate by the hand, the phenomena will in all respects correspond with that attending the gravitative pressure, except in that the hand after a time, fatigues and refuses to longer exert pressure and hold the gas down.

§ 334. We will find also, in all these cases that if our cylinder is not stout we may easily rend it by increasing the pressure. And on a principle which we have seen applied in many other illustrations, the pressure of either kind may be increased up to within the smallest fraction of the full tension of the sides of the cylinder at which it may remain for an indefinite length of time. In such case, the two opposing tensions will stand so related in quantity, that all the time, almost, the whole of the cohesive tension of the sides of the cylinder will be overcome and destroyed by the tension of the gas. Laying another pound weight on the piston will so increase the tension of the gas that it will force the walls to give way. But if we will first hoop the cylinder with iron, or wood, or a rubber band, or the arms of a man, we may pile many pounds on the piston before the walls of the cylinder will be ruptured. Here, evidently, the cohesion of the iron or wood, the elasticity of the rubber, or the muscular strength of the man, all play the same part and fill the same office. They each re-enforce the cohesive tension of the cylinder walls, and in each case the opposition offered by the cohesive tension and the supporting tension become indistinguishable and separately untraceable. But as all the time the muscular strength of the man fails after a while, the walls of the cylinder, in that case, losing their re-enforcement, go to pieces. If, however, while the walls are on the very verge of rupture, when the addition of another grain's weight to the piston, or the very slightest relaxation of the supporting tension would precipitate the catastrophe, the piston, with its weights should be lifted, immediately the cohesive tension of the cylinder walls will be again manifested in full volume. Indeed, in the cases of the rubber band and the man's arms, what were before supporting and commingling tensions will instantly become opposing tensions; the elasticity of the band and muscles of the man will press against the outside of the cylinder all around, and may even be of strength to overcome the cohesive tension of its sides and crush them from without inward.

§ 335. Now the general conclusion from the behavior of these various tensions would seem to be that they are manifestations of force which are exhausted, or lost to our ken in the using. That such is always the case with gravity, the most irrefragable proof has been offered; and we know it must be so with muscular force, for we have the hourly experience of its exhaustion. We know that when we strike a hard blow with the hand, something goes out from us, that a portion of our strength leaves us. But in the illustration, the other tensions behave like those of gravity and muscle, so far as increasing or resisting the tension on the sides of the cylinder are concerned.

§ 336. So, too, we have seen that when gravitative force is passed off as pressure, it is continually replaced, and that when muscular strength is exhausted it is again renewed. So it must be with the tensive pressure of the gas, the cohesive resistance of the sides of the cylinder, and of the wood or iron, or steel spring, or rubber band, as the case may be. And such must be the nature of pressure and of resistance to pressure. If not this, then it would be, as the only alternative, a single impulse forward which would pass and leave nothing behind. Indeed, *pressure* is a notion which seems never to have been clearly defined or grasped in human thought. It has been regarded as something which could act continuously without exhaustion, and without need of renewal, just as gravity has been regarded. As we have elsewhere seen in discussing gravity, this in thought is really educing something from nothing. Yet it is necessarily either that or the admission of the continual coming in of these forces from outside of what we know as material nature.

Law of Mariotte.

§ 337. But to get back to our illustration: If we let the gas expand into twice the volume, that is, to the capacity of a two-gallon cylinder we shall find it will not support the ten-pound piston but one only half so heavy; and so, likewise, will the pressure on the sides and bottom be only half so great. But if, on the contrary, we compress the gas to half volume, that is, into a half gallon space, it will support a twenty-pound piston, and the pressure all around will correspond. This is in strict accord with the law of Mariotte, or rather it is that law itself illustrated.

Law of Charles.

§ 338. But the discussion so far proceeds upon the hypothesis that the temperature of the gas is the same throughout, for when we come to deal with it at different temperatures the law of Charles comes into play.

By this law, if one gallon of gas at the absolute temperature of 273° C. will sustain ten pounds, at double the temperature (546° C.), it will support twenty pounds, and the pressure on the sides of the vessel will likewise be twice as great. But if the gallon of gas stands at 0° C. it will support only five pounds, and press only so much on the inside surface of the cylinder.

So it will be observed that one gallon of gas at the temperature of 546° C. exerts, or will support, just the same pressure as will two gallons compressed into one and at the temperature of only 273° C. On the other hand, cooling the one gallon down to 0° C. has the same effect on its pressure as letting it expand into double volume; for in each of these instances, it will support only five pounds, and its tension is only so much.

§ 339. But in all these relative measurements we must consider the gas as having, at the time, accomplished the change of volume, tension, or temperature, as the case may be, without the result of relative measurement given. For during the process of change of volume, tension, or temperature, other laws are manifested, thus:

When a gas expands, temperature sinks; when it is compressed, temperature rises. But the sinking of the temperature decreases the tension and the raising of the temperature increases the tension.

One gallon heated from 273° to 546° under the same tension would, if the temperature could be sustained, expand to twice the volume; but in fact, as the expansion goes on, the temperature is reduced and with it the tension; so that, unless the temperature can be in some way kept up from other sources, it cannot reach double the volume with the same, nor anything like the same tension.

On the contrary, if the one gallon at 546° could be cooled to 273° under the same pressure it would support just half the weight. But in experience, as it is cooled it is compressed, and by the act of compression the temperature is raised, and as the temperature is raised the tension is increased. And so, unless some of the temperature has opportunity to escape, the tension cannot be reduced by cooling.

§ 340. In conclusion, the result of the discussion in this chapter is the same as everywhere else. Forces new and old come and go, ebb and flow through Nature, from whence we know not, to where we know not. And again, Conservation is invalidated.

CHAPTER XVIII.

HEAT.

THREE PRINCIPAL MODES OF FORCE—PRESSURE—HEAT—KINETIC FORCE—KINETIC THEORY OF HEAT—PROPULSIVE THEORY—CHEMISM—PROF. COOKE—ABSORPTION AND DEVELOPMENT OF HEAT—ATOMIC FORCES—HEAT DOES NOT METAMORPHOSE—HEAT FROM IMPACT—FRICTION—CARNOT'S THEOREM.

The Modes of Force in Gas.

§ 341. There are three principal modes of force exhibited in the conduct of gases, Pressure, Heat, and Kinetic Force. Pressure is always an out-going force, not carrying matter along, but passing through it in *effort* to carry it along. Being an outgoing force it must be a continually incoming force. But where it goes to, or where it comes from, are beyond our tracing.

§ 342. Heat has three prominent characteristics:

First, it is an expansive force driving and holding the atoms or molecules of matter apart ; Second, it passes through masses of matter in all directions by *conduction ;* Third, it radiates into space on right lines in every direction. It also has an identity and continuity in an altogether different aspect from Pressure or Gravity. It is not simply a passing phenomenon as they, but, to a greater or less extent, an abiding and continuing factor. Pressure and Gravity change identity momentarily, but Heat may retain its identity for an indefinite length of time.

§ 343. The other prominent mode of force is Kinetic or Molar Force. It acts in volume in translating bodies of greater or less mass through space. It abides in the moving body so long as the motion continues unchanged, though liable to continual modification by composition with other forces. When other bodies are interposed in the path the kinetic force is determined by impact, with resulting pressure, heat, and other modes of force. All pressure tends to grow into kinetic force, and it always does so except when prevented by resistance. Perhaps we have no experience of kinetic force originating otherwise than from pressure, that is, by the same forces which produce pressure going on to produce forward motion by overcoming resistance.

Kinetic Theory of Heat.

§ 344. The effort will now be made to get as clear a comprehension of the kinetic theory of heat as applicable to gases, as possible, concerning a subject so obscure. The kinetic theory seems to rest on two quite distinguishable supposed principles, the first that of the rectilinear motion of the molecules of gas under laws laid down as follows :

Prof. Cooke : " The molecules of a body are not isolated masses in a fixed position, all at rest, but, like the planets, they are in constant motion. The greatest length of path over which this motion can ever extend must be exceedingly short, so short, indeed, that if the path could be traced, it would be wholly imperceptible to our senses, even when aided by the most powerful instruments. But, nevertheless, the motion is none the less real, and none the less capable of producing mechanical effects. In a gas the motion of the molecules are supposed to take place in straight lines, the molecules hurrying to and fro across the containing vessel, striking against its walls, or else encountering their neighbors, rebounding and continuing on their course in a new direction, according to the well-known laws which govern the impact of elastic bodies. Of course in such a system all the molecules are not moving with the same velocity at the same time ; but they have a certain mean velocity, which determines what we call the temperature of the body and the higher the temperature the greater is this mean velocity ; moreover, the mean velocity of the molecules of each substance is always the same at the same temperature." *New Chemistry*, p. 37.

Prof. Wurtz says : "Mariotte's law follows as a natural consequence of this hypothesis upon the constitution of gases. If a gaseous mass composed of an immense but determinate number of particles, is contained in a closed space—the cylinder of an air-pump, for instance—the pressures exerted upon the piston will be determinated by the normal components of the impact of the molecules during a unit of time. If the volume of this gas is reduced the number of particles will increase * as well as the number of impacts : the pressure will, therefore, undergo a proportional increase.

"The volume remaining constant, the pressure will be also increased by an elevation of the temperature. Under these conditions the number of the particles remains the same ; their masses remain constant, but their velocities, and, consequently, the number of impacts, is increased, and it is precisely the *vis viva* or the total energy of the molecular motions which give a measure of the temperature."—*Atomic Theory*, p. 315.

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* Evidently the author here means to say that the number of particles is increased relative to the lesser space occupied.

§ 345. The second basis of the kinetic theory of gas temperature or pressure is the hypothesis of the passage of heat into the moving particles of the gas in a latent or potential form, its transference to any body which may take on translation as kinetic force, and its reconversion into heat when any such motion may be arrested.

§ 346. To the first part of the theory above Judge Stallo, with great force and acuteness, urges the objection, that the atom being the smallest conceivable portion of matter must be rigid, since it cannot have parts which can be compressed in upon each other; but, if rigid, any gas would soon lose its tension, since the inelastic atoms continually colliding with each other and impinging upon the sides of the containing vessel would have their motive energy rapidly transformed into heat. By this process it would seem that a gas should become self-heated and inelastic.

But Judge Stallo has not reached the idea that all resistance of Elasticity involves both the expenditure and reception of force as we have found must be the case.

§ 347. Another objection may be stated: The theory supposes that the pressure of a confined body of gas is caused by the bombardment of the sides of the containing vessel by its rapidly moving molecules, and that, when such pressure lifts the piston in the cylinder, it is by virtue of the motive force of the gas being transferred to the piston through the process of this pelting of its lower end by the molecules. Now when at the same pressure, one measure of gas has twice the temperature of another, it is said that in the hotter gas there are only half as many moving molecules, but their motions being on the average twice as rapid, the effects on the sides of the respective containing vessels are the same.

But where under the same temperature the pressure of one volume of gas is twice as great as that of another equal volume of the same gas, it is explained on the hypothesis that with the same average velocities there are twice as many flitting molecules in the one volume as in the other, and twice as many impacts on the same extent of interior surface. And if the more tensive gas is permitted to expand, at the same temperature until its pressure is just equal to the other, it is said, that it is because the average number of impacts to the same extent of surface is now equalized.

But it is a geometrical principle that while the surface of any regular solid varies as the square of any homologous dimension, the contents will vary as the cube of the same dimension. If we suppose a cube of gas one foot each way, and another of the same gas at the same temperature and tension two feet in its three dimensions, the latter will have eight times the solid contents, but only four times the interior surface of the smaller cube, and there will be in it eight times as many moving molecules, and, consequently, eight times as many impacts on four times the extent of surface and the pressure will of course be as 8 : 4 instead of 4 : 4 as by the theory.

The same will be exactly true as regards any other regular solid, as a globe, while with irregularly shaped vessels the proportions will vary. Thus, if the one and two gallon vessels are very flat, broad and thin, the surface difference between them will be very small comparatively, much less than the ratio of 2 : 1. But if the vessels should be long, narrow cylinders the ratio will be very nearly 2 : 1. But no difference what the shape of the vessel is the tension, both in fact and theory, is exactly 2 : 2.

§ 347. Another difficulty seems to be in reaching, a notion as to the process by which, at the instant the piston is raised by the impacts of the molecules against it, the motions of all the molecules, in whatever part of the vessel, and in whatever direction flying, are slackened. And the same result follows if the piston be gradually lifted by the hand instead of being forced up by the tension of the gas. Indeed, in this instance, the difficulty seems greater, for in the former case the theory is that the heat-motion or heat-force of the impinging molecules passes into the piston as molar motion, and, of course that in some way the motion lost by these molecules is made up to them by an equable distribution of motion from the other molecules. But in the latter instance, it cannot be claimed that the impinging molecules lose any force in lifting, and the query arises, what becomes of the heat force lost by all the molecules?

§ 348. Now let us reverse the operation and follow the theory. The piston is forced down from the two gallon to the one gallon mark by some pressure, say of the hand. Now what phases of phenomena are presented? The first of course is the compression; the molecules are forced nearer together. Tension is overcome and at the same time tension is increased. Another is, a double tension or pressure by reason of this compression against the inside surface, which remains as long as the piston remains at the lower mark. Another is, the heating of the gas; and, still another, the increase of the tension by reason of this heating. By the theory the energy exerted by the hand becomes kinetic motion in the piston, carrying it down against and overcoming the upward tension of the gas, and then is converted into heat in the gas, increasing the speed of its molecules. Now, of course, any idea of how this downward motion of the piston is transmitted to the molecules, giving them motion in all possible directions and velocities must be very obscure indeed. Equally vague must be all ideas of how the motion of the molecules is transmitted as radiation in cooling.

New Theory of Heat.

§ 349. Suppose, now, a theory should be propounded of this kind: Heat is a stable, expansive, repulsive, and dispersive force, antagonistic to the different forms of attraction, and is always trying to get away from itself by conduction or radiation, as if moving from every point as a centre, like as gravitation is always endeavoring to get together or accumulate itself. The accumulation of heat is temperature, and, as the temperature rises, so does the effort towards self-dispersion or expansion. A confined gallon of gas at 273°C. is heated to 546°C., that is heat is accumulated in it to double quantity, and we call it double temperature. In that proportion the tendency to dispersion by radiation is increased and it will, through this process, be distributed very rapidly if we do not take precautions against it. But while the temperature remains at 546° the tendency to get away from itself by driving the molecules from each other is also doubled, and this redoubled effort to get away is the cause of the redoubled pressure against the sides of the vessel.

But if the gas is permitted to expand to double volume, the pressure is only half so great because the same quantum of heat filling double the space has only one-half the tendency to get away from itself; and the temperature is only half so great, because temperature being but an expression for heat accumulation, that accumulation is only half so great. Now, if the gas be again compressed into the one gallon, the accumulation into half the space of the heat which was trying to drive the molecules apart gives us higher temperature; while the fact of its being thus brought nearer together again intensifies the effort to get away from itself.

§ 350. But it becomes necessary to the perfection of this theory to predicate two elements or phases of phenomena for heat, the one that we have been calling Heat or Temperature, a force having a permanent identity; and a something which we have called Pressure, continually growing up out of it, and as continually either passing into kinetic force or being resisted by *contra* pressure, and overcome and exhausted in the resistance.

This of course makes heat a pure force of a very definite character and stable kind, although always on the move or endeavoring to be so, and also a force out of which, when resisted or hedged in by opposition, continuously grows up another mode of force called Pressure, of the same order of force as gravitation or cohesion; that is, an order of force distinguished by a continued coming in from some untraceable background, acting, and continually passing out into some untraceable foreground.

Chemism.

§ 351."The falling back from a less stable to a more stable condition is always attended with the evolution of heat, whether the change results from the spontaneous decomposition of a single complex compound, or from the concurrence of several in a chemical reaction."—*New Chemistry*, p. 357.

"The atoms of which the molecules of the elementary substance consist must be drawn apart before they can form new molecular groups, and the resulting thermal effect will depend on whether the amount of heat absorbed at the parting is greater or less than that evolved at the new union. If it requires a larger amount of heat to part the atoms of the molecules of the elementary substances than that produced by the subsequent union of the atoms to form the molecules of the compounds resulting, then the total effects will be an absorption of heat, and the formation of such compounds from elementary substances always involves a loss of energy in the form of heat. This is especially true of the compounds of nitrogen, for nitrogen gas is a more stable substance than most of compounds containing this element. In most cases, however, the formation of a compound body from elementary substances is attended with the evolution of heat, and thus we come to classify chemical compounds into *exothermous* compounds, whose heat of formation is a positive quantity, and *endothermous* compounds, whose heat of formation is negative." —*Ibid*, 361.

That is to say, when the atoms of the old elements are held together with a tighter grip than the atoms of the new compound heat is absorbed and disappears, but when the tenacity of the atoms of the new compound is greater than in the originals heat is developed or disappears in the process. And this accords with the explanation given of the behavior of heat in gases. When atoms are forced apart by heat as in passing from a more to a less stable condition, the heat in the process gets away from itself—that is, it expands, carrying the atoms with it, and shows itself less in temperature, in passing off by radiation or conduction. But, on the contrary, whenever the atoms are drawn into nearer juxtaposition, the heat contained in them or surrounding them, as the case may be, not having the same work to do in holding them apart, is turned out of doors as it were, is squeezed out, manifests itself, and passes off the more readily as temperature by the processes of radiation and conduction.

§ 352. And it must be noted that there is all the time and everywhere a struggle between heat and the atomic force by which matter is held together in molecules as well as in larger masses. Heat is always endeavoring to push the atoms and molecules apart, away from each other, to expand them in space, while the atomic and molecular forces all the time tend to drive them together. But heat has other tendencies or properties which "attractive forces" do not possess. It is always ready to let go of the atom or molecule it is pushing outward, and pass by conduction through contiguous atoms, to some body where less heat is present, or else to strike out in right lines through space. On the contrary, the opposing force in the atom or molecule simply drives and holds it to its neighbors, or endeavors to do so, under certain obscure chemical laws of combination, and with certain not well ascertained intensities. And no doubt, with these concentrating forces certain laws not yet ascertained, of increase and diminution of intensities obtain relative to the increase or diminution of the relative distances. Whether there be laws of like character governing the intensities of heat would seem to call for a negative answer.

Atomic Forces.

§ 353. The behavior of these atomic and molecular forces seem to be very analogous to that of gravity, cohesion, and elasticity. They are *hold-on forces* and are what they are only while in the particular habitat of the atom or molecule. If they get out of that at all, it is in the changed mode of pressure or kinetic force. And this "hold-on" principle must be a continually growing up or coming in principle, just as is the muscular "hold on" force of the hands, and also a force which is continually exhausted in the doing, in the holding on, just as with muscular strength, gravity, or the elasticity of the bow. It has been shown elsewhere, how any other notion arises from failure to get a clear cut idea of these forces and how they act.

Heat does not Metamorphose.

§ 354. And, according to this view, heat is never anything else than heat; it is heat the first we know of it, as long as we know of it, and the last we know of it. It is true, that its form or mode is often masked in what is called latent or specific heat, but this is by reason of the fact that it is doing a character or intensity of expansive work that does not give play to its manifestation as temperature. It does not itself ever become kinetic force, though it does, under certain conditions, form a basis or nidus for the outgrowth of Pressure, which all the time, as has been elsewhere shown, tends to become kinetic, and in any instance is retained therefrom only by opposing forces. And as heat does not become kinetic force, so kinetic or molar force does not become heat. Whether pressure in the interior of the Sun and of the depths of the Earth may not metamorphose into heat we do not know.

Scientists claim, as we have elsewhere seen, that condensation produces heat.

Condensation.

§ 355. But they do not seem to look to the *pressure* resulting from condensation, but the stoppage of the kinetic falling together of the particles in condensation, as the particular characteristic of this process which results in the manifestation of heat. Thus says Prof. Merriman in the article heretofore quoted from:

"Again the cessation of motion evolves heat. It is well known that by skillful blows with the hammer a cold iron bar can be made red-hot. Two wheels revolving in opposite directions, and touching at the circumference, become highly heated; and factories have been warmed solely by this transfer of motion into heat. Friction is but another name for the arresting of motion, and, as we well know, always produces heat. There is also here the same equivalence as in the other case. The stoppage of motion evolves just the amount of heat that was required to produce the motion."—P. 704.

§ 256. As remarked above, it is not known what becomes of the gravitive pressure-force which is continually passing downwards towards the centre of the Sun, Earth, and other planets. There are grave difficulties in the way of the theory that it is converted into heat in the depths. The laws governing electricity and magnetism are too obscure to give tangible basis for an opinion as to a theory of their correlation with this force. And yet it seems clear, not only that it ceases to manifest itself as gravity, but that the only alternative to its correlation with some one or more of the great terrestrial forces mentioned is its dissipation into the realms of the unknown and unknowable.

Now Prof. Merriman illustrates his notion of the evolution of heat upon the stoppage of motion by examples of impact and friction. Perhaps he means no more, for certainly there is a stoppage of motion in all the planets from perigee all the way to apogee, but it is supposed that no one will insist that these bodies are heated up by the slowing down of these motions as they proceed further and further from the Sun!

Heat from Impact.

§ 357. Heat is an expansive force whose chief office seems to be to resist molecular cohesive forces. It is propagated in three principle modes, by radiaton, by conduction or passing through the substance of bodies, and by conviction or being carried by moving particles from one part of a body to another. The most important sources of terrestrial heat are the sun, the interior of earth, impacts, frictions, compressions, and chemical actions including combustion.

§ 358. It is claimed by the current theory of thermo-dynamics that in every case of impact or friction between non-elastic bodies, all that portion of the kinetic force not transferred and continued as kinetic force is converted on the instant into heat, and that in every such instance, if the heat so developed could all be gathered up and reconverted into kinetic force, it would, when added to the remaining kinetic force, just equal the original measure of the force of impact.

It is also claimed that this has been demonstrated by the experiments of Mr. Joule and others. As these experiments will be referred to hereafter, it is only needful to say in this place that it has already been shown that the supposed measure of force established by Mr. Joule is arbitrary and deceptive.

There can be no question that, generally, in impacts and frictions of hard inelastic bodies heat is developed. It is also true that, generally, in compression and trituration of solids, heat is likewise produced. Whether there be any instances of compression which does not develop heat, or whether simple pressure without compression ever developes it, seems not to be clear. It may also be doubted whether heat is developed by either impact or friction where there is neither compression nor trituration. Says Prof. Porter Poinier: "Rumford states that the heat generated in friction is exactly proportional to the force with which the two surfaces are pressed together and to the rapidity of the friction." *Pop. Sci. M., Dec.*, 1877, p. 216. This is no doubt true. No doubt there is an exact numerical equivalence between the forces engaged and the heat developed, but this does not demonstrate identity of essence. However, this quotation is made to show that Rumford recognized what his disciples seem to ignore, to wit, that the forces engaged are not *all* converted into heat; but a part into pressure, and, as such, passed or conveyed away.

Heat a Mode of Motion.

§ 359. Perhaps here is as good a place as any to notice another hypothesis of the scientists,—that "heat is a mode of motion." Says Prof. Merriman: "Recent discoveries have shown not only that motion is heat transformed, but that to produce a certain quantity of motion an invariable certain quantity of heat is required."

And Prof. Tyndall entitles one of his very able works on Physics: "Heat as a Mode of Motion." Science has demonstrated that one of the manifestations of the presence of heat is undulatory or vibratory motions in the particles or atoms of matter, and it may be that such undulatory motions are the invariable concomitants of the presence of heat; and not only so, but that the intensities of such motions may be the exact measures of such heat. But this, if so to the fullest possible extent, does not prove that such motions, or any motions, and heat are the same thing in identity and essence. The most that it can be taken to prove is that heat is the *cause*, the source determining or compelling such motion. The notion that heat and motion are one, that they are only different forms or modes of the same essence, entity, or existence, is but the Forceless, Causeless, Mindless, Godless, fatalistic theory of the Universe elsewhere discussed. In the language of Emil Du-Bois-Reymond, it is the "unpitying drift of nature without gods." It is a theory not called for by any phenomenon of either heat or motion, not demanded by any single fact in nature, set up in opposition to the necessary laws of thought, and only useful as it would seem, as a crutch to Conservation.

§ 360. But another proposition of Prof. Merriman's needs to be noticed; that is, that all motion is a metamorphosis of heat: "To produce a certain quantity of motion an invariable certain quantity of heat is required;" and again: "All motion that we are familiar with requires the expenditure of heat." Would not some fact showing how heat is expended in gravitation have been better than this assertion? Is there any fact showing or tending to show that either the orbicular or rotatory motion of the planets require "the expenditure of heat?"

Heat from Impact.

§ 361. The behavior of the forces concerned in several illustrations, may now be investigated. Take that of the heating of an iron ball fired against a target of steel, where it is claimed that the whole of the kinetic force is converted into heat. Evidently there is a certain degree of compression, both in the forward side of the ball and in the target, that is, in both the particles are forced out of place and driven in more closely upon each other; also a portion of the force is passed off as pressure through the substance of the target. Another portion is converted into vibrations or tremors in the particles, as evidenced by the loud noise of the impact. Here, then, are four different characters of phenomena, resulting from the impact. First, compression of the substance of both the ball and target; second, pressure passed off through the material of the target; third, tremors in the substance of the target, a part of which are communicated to the atmosphere producing sound; and fourth, heat.

And a closer analysis shows us that it is not the kinetic force of the moving ball alone which is concerned in the production of this series of phenomena. Besides, there are the following, if no more, connected with it: the cohesive forces in the ball, for they are to a certain extent overcome and broken up; the cohesive forces in the target, and the contained heat of both ball and target; for it is a first principle that heat is always present in all bodies.

It follows, therefore, in the first place, that the whole of the kinetic force of the ball is not converted into heat, because a portion of it is utilized in the production of these other phenomena; in the next place that there is no known method of ascertaining what portion of this force passes into these other phenomena; and in the last place, the query arises whether the heat appearing may not be educed from one of these other sources.

§ 362. And so in every instance of impact which may be examined. There are always several forces concerned and several phenomena produced, and science has as yet no test fine enough to follow each mode of force through each form of phenomenon and ascertain the relative part it plays; and, evidently, any assumed formula must be a deceptive basis for a philosophical system. And yet the books are full of assertions by scientists, many of them deservedly celebrated for their great achievements, that there is an exact numerical and quantitative equivalence; and, not only so, but that the whole of the kinetic force, upon impact, metamorphoses into heat.

Friction.

§ 363. In friction, both the forces and phenomena are somewhat varied. In addition to the forces concerned in impact, there must be a pressure present; and the kinetic force, instead of being a simple forward force producing impact, is strictly *molar*, a grinding or rubbing force. And usually, one of the results of the friction is the tearing apart to a greater or less extent, of the surface particles of one or both the bodies; that is, of a trituration to a greater or less degree. The pressure-force is wholly, or nearly so, propagated forward *as* pressure. A part of the kinetic force, also, as in impact, passes off as pressure. This will be apparent when it is remembered that without the resistance of some body there could be no friction. In the rubbing of the surfaces the tendency is to tear the particles asunder; so far as they yield to the force, it is trituration, so far as they resist, it is pressure.

In the use of the brakes on railroad trains, there is in play, the pressure between the rubber and wheel, the grinding motion of the wheel on the rubber, the cohesive forces in the material of both, and the contained heat of both as before. The resulting phenomena is the expenditure of the forward force and stoppage of the train; a pressure strain on both rubber and wheel, propagated through connected mechanism; a wearing or tearing awayof the surfaces of both; and vibratory motion giving rise to noise, electricity and heat. So that, when science attempts to say that all or any definite portion of the forward force, or motion, as it calls it, is converted into heat by the application of the brakes, it is stepping over its present limits. And as neither all nor any particular part of it can be traced, and indentified, it follows, that, so far as science knows, some of it may be lost in the catastrophe.

Vibrations.

Indeed, there is one portion of this force which so far as science can now penetrate, does seem to be lost. That producing vibrations or undulations in the substance of the opposing bodies is referred to. It is true that this is generally said to metamorphose into heat. But a little consideration will show that this notion is probably erroneous. Heat is itself supposed to subsist in matter as a very high mode of undulation or force producing such undulation, much higher than that concerned in the production of sound. If this be true, it is not seen how the lower or slower order of undulations can be converted into the higher or more rapid, since the tendency, all the time, is to expansion and dissipation, as is the tendency in heat itself.

Impact and Friction.

§ 364. The true conception seems to be that all the heat developed by the processes of impact and friction is instantanously produced by reason of the fact that the molecular forces in one or both surfaces are broken up by the suddenness of the arrest of kinetic force in the one case, and the tearing apart of the particles by molar force in the other.

That the heat is developed not simply by the stoppage of motion, but by molecular disturbances in colliding surfaces, seems established from several considerations. These surfaces only become heated. Hammer an anvil with a hatchet, and the head and not the blade of the hatchet will grow warm. Yet motion is arrested in the one coetaneously with the other. Meteorites are usually found to have been heated on the surfaces to the melting point by heat developed on impact with the atmosphere, yet it is recorded that they have been picked up hot on the outside, while intensely cold within, showing that the impact affected only the surface.

"Meteors are not incandescent when they reach the ground, but are still too hot to handle. Sometimes the high temperature is limited to their surface, while within they are extraordinarily cold. The spectators of a meteoric fall at Dhurmsalla, India, on the 14th of July, 1860, eagerly broke up the stones, still burning hot on the outside, and were greatly surprised to find that it was impossible to handle the inside parts on account of their extreme coldness. A similar observation was made on the 16th of May, 1883, at Alfianello, near Brescia. This contrast between the central part, still retaining the intense cold of the planetary spaces, and the outside, which only a few moments before had been red hot, may be easily understood, when we reflect on the feebleness of the conducting powers of stony substances, and the very short time that they had been heated."—*M. A. Daubrée*, *P. S. M.*, July, 1886, p. 377.

Metamorphoses.

§ 365. There will be no attempt to enter into an extensive discussion of the metamorphoses of forces. That all pressure tends to pass into kinetic form, and upon all impacts and frictions a part at least of the kinetic force passes into pressure, have been shown. The origion of the heat developed in impact and friction, is very obscure, and demands more exhaustive research and consideration than it has yet received. When we reflect how pressure and kinetic force pass into each other, and how very different are the characteristics of heat force from either, the theory that a part of the kinetic force of impact or friction metamorphoses into heat seems hardly satisfactory.

Potential Heat—Force in Coal.

§ 366. It is a favorite theme with scientists that all energy is derived from the sun, and that in plant-growth heat force is laid away in potential form in the carbon of the vegetable substance, to reappear, thousands of centuries after, it may be, as heat in combustion. And they expatiate on the wonderful proposition that this heat, stored away in vegetable coal so long ago, may, by means of combustion and through the mechanism of the steam-engine, be made to pass into steam to drive the piston in molar motion, and do various kinds of work, in which processes the heat reappears, not only in equivalent quantity with that stored by the sunbeams in the vegetable fibres, but in the essence of existence *the very same.*

Thus, Wm. Lant Carpenter says: "Another instance is the decomposition or dissociation of carbonic acid" (Carbonic Dioxide) "by growing plants, under the influence of light, when the oxygen is set free, and the carbon enters into the substances of the plants, forming thereby a store of potential energy." —*Energy in Nature*, p. 86.

Again: "Hence when wood is burned the energy thus generated is simply a *reproduction of the solar energy*, which separated the carbon and oxygen during the growth of the plant."—*Ibid*, 180.

"Now this line of argument may be carried back into those distant geological ages when the mighty forests flourished which now form coal, that great store of our national wealth and vast storehouse of potential energy."—*Ibid.*

A wonderful fact, if fact it be, a beautiful theory if only a theory. Let an examination show which.

Steam Engine.

§ 367. The steam-engine is a machine in which an alternating molar motion is produced in a piston rod by alternating steam pressure on the opposite sides of the piston-head, and this is effected by alternately utilizing the heat of combustion in making steam, and then by the use of the condenser, retiring or withdrawing it from the steam; so that the real motive power is not the steam, nor yet the heat in the steam, but the pressure-force which is born *of* the heated steam.

Now in some unknown way, stimulated by beams of *sun-light*, the chemism in the leaves of the plant, under the control of a directive principle therein, take to pieces the carbonic dioxide brought to them by the atmosphere, rejecting the oxygen and storing the carbon. Here the first thing to be noticed is that this process goes on under the stimulation of *sun-light* and not of *sun-heat.*

§ 368. It may next be noticed that there is no evidence that any measure of heat whatever is stored in the carbon of the plant *as potential energy.* Of course, when the carbon is taken out of the carbonic dioxide, there is a readjustment of the heat force and so much as is necessary to hold apart the molecules of the carbon against antagonistic molecular forces so as to *make* carbon of it, is utilized, and for all the ages since, it has been, not stored as sleeping, silent, dead, potential energy, but doing its active work in pushing against cohesive forces. And it may be further observed, here, that the evidence entirely fails to show that any part of this heat so employed is the *same* heat which fell on the leaves of the plant or even that there is any quantitative equivalence between them.

§ 369. The next stage is combustion, and what does that mean? Why, that this same carbon unites again with a portion of the oxygen of the great atmospheric ocean to form another portion of carbonic dioxide, and that, in the process there is another great readjustment of heat forces: just as heat has all the time been holding apart the molecules of carbon, so other and larger portions of heat have been holding the molecules of the oxygen still further apart. But now in this union, so much heat as is present in both the carbon and oxygen, is not needed to hold apart the molecules of the carbonic dioxide being formed, and the surplus over is manifested as the heat of combustion, which is certainly derived as largely, and probably many times more largely, from the oxygen than from the carbon consumed.

This is acknowledged by Wm. Lant Carpenter who says: "In connection with these processes in the growth of plants, and the so-called storage of solar energy in wood and coal, it should be remembered that the energy really lies in the separate existence of coal or wood and oxygen, and therefore in the oxygen as much as in the coal."—*Energy in Nature*, p. 200.

§ 370. Now a part of this excess of heat, set free in combustion, enters into the particles of water driving and holding its molecules apart in the form of steam which presses on every portion of the inner surface of boiler and cylinder. And this pressure is a continual force acting against these surfaces and being resisted by the walls of boiler and cylinder until the piston-head, which may be considered a part of the cylinder wall, gives way, moves, recedes, pushing the piston-rod before it. Here then molar motion is set up and molar force manifested. But whence is it? Evidently it is not a metamorphosis of the heat which has made steam out of the water, for that is yet in the steam. The alternative seems to be that it is a result or metamorphosis of the pressure-force which grows up and flows out from the heat expansion of the steam, just as it grows up and flows out from any other pressure in its effort to pass into kinetic force.

§ 371. But now another step. The steam is let into the condenser, a spray of cold water plays into it, the heat leaves the steam to pass into and warm up the water, in consequence of which the steam is itself condensed into water and a vacuum is formed in condenser and cylinder. But immediately steam is let into the other end of the cylinder behind the piston-head and the pressure-force growing out of it drives the piston-head forward into the vacuum, pulling the piston rod after it. And then a valve is opened, and this steam is in turn let into the condenser and converted into water by the abduction of its heat.

§ 372. Now the piston-rod being connected with appropriate mechanism, by its motion back and forth, produces any kind of motion in machinery necessary in running locomotive, spindle, loom, or trip-hammer. But both in the gearing and bearings of the machinery and in the materials operated upon, there must be much of friction and impact with the attendant development of heat. The question of the evolution of heat from these processes has been elsewhere considered, and some of the difficulties of the current theory pointed out. It only needs to further remark here, that if the heat evolved in this instance is a metamorphosis at all, it can in no event reach back further than to the pressure-force educed from the steam-pressure.

§ 373. To repeat the steps of the processes just recounted, we have: 1. Sun-light to begin with; 2. Dissociation of the carbon and oxygen of the carbonic dioxide with a liberation of oxygen, storing of carbon, and a releasing of heat which is simultaneously reabsorbed, together with larger measures of the same from other sources by the two dissociated elements; 3. Combustion in which carbon unites with other oxygen to form a new measure of carbonic dioxide, with a liberation of a larger quantity of heat from the two elements, and a coetaneous reabsorption of a small quantity of it by the new compound; 4. The formation of steam as the effect of the absorption of the liberated heat by water; 5. The up-growing of pressure-force in the steam and the struggle of the same to pass into molar force; 6. The transformation of this pressure force into kinetic force and the production of molar motion as the result; 7. The condensation of the steam and consequent retirement of its heat force; 8. The manifestation of the heat of friction and impact.

Now it is evident that in this series of changes of phenomena there can be no quantitative equivalence, much less sameness of essence throughout. In the first place, there is no safe ground for asserting that the sunbeam which stimulated the action of chemism in the leaf, or any part of it, is stored in the carbon, or that the heat there utilized is not partially or wholly from other sources. In the next place it is certain that heat exhibited in combustion is not *all* liberated from the coal, but, on the contrary, that the larger part of it is given up by the oxygen. Again, it is certain that comparatively but a small portion of the liberated heat makes steam. Much of it is, in spite of all precautions, radiated off, some of it lost in heating up the mechanism used in producing and applying it, and some of it in heating the water that does not pass into steam. Then it is here contended that all of the heat which is utilized in making steam, except what is lost by conduction and escape of steam, is again retired in the condenser. And it is very certain that whatever may be the nature and source of steam pressure, never so much as a moiety of it can be used to produce molar motion in the piston, for always more than a moiety will be engaged pushing upon the walls of the cylinder. Once more, it is unquestionably true, that all of the kinetic motion of the piston is never converted into the heat of friction and impact. A part of it is always utilized or wasted, whichever it may be called, in producing other pressure, and perhaps sound and other phenomena of energy.

So that, here, again, we have a remarkably large scientific theory with a remarkably small measure of fact to support it.

CARNOT'S THEOREM.

§ 374. But the steam-engine is deserving a much more careful study, particularly in the light of Carnot's great Theorem, which is thus explained by Prof. Tait: "The hypothetical operation which Carnot introduced for the purpose of reasoning on this subject, is, like most great ideas, excessively simple—*when found*. Let us imagine two bodies, each maintained constantly at a definite temperature.

These will be called the hot body and the cold body respectively. In addition to these, suppose a body which, as regards other bodies, is neither cold nor hot, being incapable of absorbing heat or of giving it out—a body which is a non-conductor of heat. Suppose the walls of the working cylinder and the piston to be non-conductors of heat, but the bottom of the cylinder a perfect conductor. Suppose a quantity of water and steam in the cylinder, both at the same temperature, that of the cold body. Place the cylinder on the non-conductor and expend work in pressing down the piston, the contents will become warmer, and some steam will become liquified. Continue this process till the temperature rises to that of the hot body—then transfer the cylinder to it. Now allow the piston to rise, then the contents remain at the temperature of the hot body, fresh steam is generated, and work is done. Arrest this process at *any* stage and transfer the cylinder to the non-conducting body. If we now allow the contents farther to expand, more work is done but the temperature gradually sinks. Continue this process till the temperature falls to that of the cold body, to which, therefore, without loss or gain of heat, it may now be transferred. Next apply work to compress it at the constant temperature of the cold body till (by condensation) the contents have become exactly as they were at starting. The cylinder must now be transferred to the non-conducting stand, and everything is as it was at first—save that some heat was taken from the hot body in the second operation, and heat was given to the cold body during the fourth. Also it is evident that *more* work has been done during the second and third operations than was spent in the first and fourth, for the temperature, and therefore the pressure of the contents was greater during the expansion than during the compression. Of course this operation may be repeated any number of times.

"Notice particularly what the peculiarity of the operation is. The steam or expanding substance, whatever it is—for air or anything else would do equally well—must always be in contact with bodies of its own temperature, or else with non-conducting bodies. If it were in contact with a body of lower temperature, there would be a waste of heat. Heat would pass by conduction from the cylinder to external bodies, and would of course be wasted as regards work. The same would happen if the cylinder were to be removed from the non-conducting body and placed upon the cold body, before its contents had been allowed to expand sufficiently to cool down to the temperature of the cold body: some heat would then be conducted away at once and be lost to the engine. So, throughout the whole of Carnot's operations, it is essential that there should be no direct transfer of heat at all except while heat is being taken in from the hot body or given out to the cold body: the temperature of the contents of the cylinder being in each of these cases the same as that of the body with which they are for the moment in contact.

"Now we come to another point, also perfectly novel, and of great importance. Suppose the operations in Carnot's cycle to be performed in exactly the reverse order. Begin, for instance, with the hot body, but do not allow the piston to rise there. Take the cylinder from the hot body when the water and the steam below the piston have acquired the higher temperature. Lift it to the non-conducting body, and then allow the piston to rise. Let it continue to rise, doing work all the time, till the temperature sinks to that of the cold body; place it on the cold body; allow the steam to expand still farther,—it will be in that case giving out work but taking in heat. When it has risen to its former highest point, place it back again on the non-conducting body, force the piston back to the same extent as that to which it rose when (in Carnot's direct set of operations) it was first placed on the body. Everything has taken place in precisely the reverse order to that in which it took place before. Finish then upon the hot body, and press home. There is sent back, in that final operation precisely the quantity of heat taken from the cold body; but during the two first operations the piston was in contact with steam at a lower temperature, and therefore at a lower pressure than during the two last. And, therefore, in the reversed method of working the engine, work has on the whole to be spent in taking heat from the cold body and depositing it in the hot body.

"These are the grand ideas which Carnot introduced. Their two distinctive features are: *first*, the idea of a complete cycle of operations at the end of which the working substance, whatever it is, is brought back to precisely its primary condition;—this cycle can be repeated over and over again, indefinitely. *Secondly*, the notion of making the cycle a reversible one, so that all the operations can be performed in the reverse order: *i. e.*, instead of taking in heat at any stage, heat is given out;—instead of work being done by the engine at any stage, work is spent on it. With these reversals of each part of the operation, the whole cycle can be gone over the reverse way."—*Heat*, p. 62.

§ 375. Of Carnot's illustration, it may, in the first place, be observed that it is not only hypothetical but in several particulars impossible, and impossible illustrations are liable to be inaccurate, inapplicable and illusive.

§ 376. But, passing this, let the several operations be followed in detail. The first: "Place the cylinder on the non-conductor and expend work in pressing down the piston, the contents will become warmer, and some steam will be liquified. Continue this process till the temperature rises to that of the hot body." It may here be noticed that it is immaterial what character of power or force is used in doing the *work* of pressing the piston down. It may be gravitative, or muscular, or the elasticity of a rubber band, or of a spring of steel, or of steam. Then attention may be directed to the fact that the pressure will be exerted upon and felt by every portion of the inner surface of the cylinder walls and bottom equally; and further, that the full amount of the pressure exerted will be added to the gravitative pressure of cylinder and piston, upon the non-conducting stand. If that stand should rest upon a steel spring it would be compressed that much the more; if suspended by a rubber band, the latter would be stretched in proportion; if hung to clock-work it could be made to do work in running mechanism; if supported by a man's arms or shoulders it would hasten his exhaustion. Indeed, if we suppose the applied pressure to just equal the combined weight of cylinder and piston, this extraneous work done in any of these modes would be exactly doubled. And not only so, but this added work in these several modes is just what would be accomplished by a like pressure exerted through a *solid* cylinder of any material whatever. We have, then, three results of this application of force on the piston; first, heat, next pressure on the walls of the cylinder, and third pressure on the non-conducting stand. And the two former results are additional to what the work would be if exerted through a solid cylinder. That is by using a hollow cylinder filled with steam we get two additional modes and measures of work. Therefore the heat developed cannot be considered the full result or measure of the pressure exerted; on the contrary, it is only a part of it; only one of three characters of the work done, if such it may be called.

§ 377. But there is still another point of view. We may suppose a series of these systems, composed of the hot body, the steam cylinder, and piston, but all without weight resting one upon another. Then any pressure, say of one atmosphere, exerted on the topmost piston, while exerting the same pressure and developing the same heat in the uppermost cylinder as before, would exert the same amount of pressure and develop the same degree of temperature in each one of the series beneath. That is to say, if the heat developed in the cylinder in the single system is to be considered the equivalent of the pressure exerted, we could by multiplying the system, multiply this heat equivalence in the same ratio, as well as the cylinder pressure. But we could not in this way increase the pressure upon the lowermost support, or increase the power communicated to our supposed clock-work attachment.

§ 378. But another feature of this process may be examined. Suppose the force exerted be a weight placed upon this piston. The steam will be compressed instantly to a certain point at which it will stand until an additional weight is added. Likewise, coincident with the compression, there will be a certain amount of heat developed with no addition until further compression. But with the other two modes of manifestation of work it will be different. The pressure on the walls of the cylinder will be continuous, and so likewise will be the running of any clock-work to which the non-conducting stand may be swung until it is all run down. So that, to heat the contents of the cylinder up to the temperature of the hot body, there will need to be repeated additions of weight loaded upon the piston, and each proportionally adding to the other two modes of work done.

§ 379. Now going back to the illustration: "Continue this process till the temperature rises to that of the hot body—then transfer the cylinder to it. Now allow the piston to rise, the contents remain at the temperature of the hot body, fresh steam is generated and work is done." Here the water and steam being both of the same temperature as the hot body when placed upon it, all the water has been turned into steam that *can* be at that degree of temperature and under that pressure or weight of piston; and as heat can only pass from a hotter to a colder body,no heat can pass from the hot body to the cylinder. The machine is locked up, the status is fixed, no work can now be done by it or got out of it until it is unlocked. How is that to be done? By doing work elsewhere with other force. By unloading the cylinder, and lifting off the pressure to a greater or less extent. When that is done the steam expands, heat is absorbed from the hot body, more water is turned into steam, and the temperature is kept at the same range. And mark that here, as before, the other two modes of work are all the time going on.

§ 380. But to the illustration again: "Arrest this process at *any* stage and transfer the cylinder to the non-conducting body. If we now allow the contents farther to expand, more work is done, but the temperature gradually sinks. Continue the process till the temperature falls to that of the cold body." Here likewise the machine is locked up. It can do no work. The steam cannot lift this piston higher till outside work is done in unloading it. But as the pressure is removed the steam expands, pushes the piston up and grows colder. And here, as before, work is constantly being done in the other two modes.

§ 381. Going again to the illustration: "Continue this process till the temperature falls to that of the cold body, to which, therefore, without loss or gain of heat, it may now be transferred. Next apply work to compress it at the constant temperature of the cold body till (by condensation) the contents have become exactly as they were at starting." Here the heat developed by the pressure is coetaneously absorbed by the cold body and as before work is done, that is, pressure is exerted both on the walls of the cylinders and on the supporting body.

§ 382. And in this case let us suppose our cold body pressing upon a series of weightless systems as a while ago, except that the supporting bodies are nonconductors instead of hot. There will be no manifestation of heat in the upper cylinder because it will be absorbed as fast as developed; but in each of the lower cylinders heat will be manifested, as before, equally in each. Here, likewise, the effects of the pressure will be increased proportionally to the number of the systems, all except that the gravitive work of the bottom system will not be changed.

It is not necessary that we analyze Carnot's reversed machine, for the same principles show out there.

§ 383. Now the supposed great value of this celebrated theorem of Carnot's lies in the conclusion that a part of the heat which expands the steam metamorphoses into the force, motion, or work, exerted or done by the ascending piston on the one hand, while the force or power which pushes the piston down is converted back into heat in the steam on the other hand. But the analysis to which it has just been submitted refutes this notion, showing, first, that during the ascent two modes of work are exhibited, the molar force of the piston and pressure on the walls of the cylinder; and, secondly, that during the descent three modes are exhibited, heat and cylinder pressure both multiplied indefinitely by repeating the number of systems, and the pressure of the basic system, which latter may readily be made to do molar work.

§ 384. And now, considering it in another view: Taking a single system, suppose the non-conducting walls of the cylinder to be of exceedingly fragile material. Of course a very slight pressure within will rupture them if not supported; and as before noticed, this support may be furnished by any kind of power even to the arms of a man, so that there is here a true antagonism of forces going on so long as the inside tension continues. Now suppose our fragile non-conducting cylinder placed inside of another of sufficient strength, with space between the walls. It is evident that we can support the feeble inside walls by letting steam into the outer cylinder, and by keeping the steam in the two cylinders at nearly equal tension both tensions may be increased indefinitely, either by adding more steam or more heat without destroying the inner walls. But by increasing one tension greatly more than the other we shall cause the inner walls to collapse, either outward or inward, according to where we have the increased tension. And all the time of this opposing pressure-work on the walls of the inside cylinder, there is a continuous outward pressure-work done by the steam in the larger cylinder on its outside walls, just the same as if it were doing no work inward on the walls of the smaller cylinder. Here, again, we see not only the antagonism of pressure, but pressure-work duplicated without any increase in the amount of the supposed working heat, or of any other applied force.

The Steam-Engine.

385. There are three ways of regarding steam or gaseous pressure. The first may be called piston-pressure. It is the measure of pressure exerted upon any definite inside surface of the cylinder and is, according to the law of Mariotte, proportional to volume. The second is the actual pressure exerted on the whole inner cylinder surface, including, of course, the piston face. As surface does not vary as volume, of course this pressureh as a different ratio of variation from piston-pressure. The third may be called absolute pressure and may be illustrated thus: Suppose a sphere suspended in the cylinder of such character that its surface would increase or diminish in exact ratio with the volume of the steam; at constant temperature the entire pressure on the surface of such sphere would remain constant through all changes of volume of the steam. Or, supposing the surface of the sphere to vary inversely as the temperature, it would in constant volume of steam receive constant pressure at all ranges of temperature. To retain the reception of a constant pressure in an ex-

panding volume of steam such spherical surface would have to increase with two simultaneous ratios: first, directly with the increase of volume, and secondly, inversely with the degree of cooling consequent upon expansion.

§ 386. "Work," as at present used in science, and in its practical sense, means kinetic or molar motion. Motion as elsewhere shown is produced by the active presence of force, of which there are only three primary kinds considered at length in this work, to wit: gravity, elasticity and heat pressure; and all of which are manifested in two modes. Gravity is pressure in supported bodies and kinetic force in unsupported bodies. Being a constantly received force it is present in all matter at all times and in inexhaustible supplies. Elasticity is known only as and when resisting some other force, and becomes kinetic only when, after having been partially overcome by such other force, it is in the act of escaping therefrom. It is constantly manifested while the resistance lasts, but disappears when the resistance does, or after having escaped from the resistance, to appear again only when the resistance is renewed. Heat-pressure, as seen in steam, like the others, when resisted all the time struggles to overcome the resistance and pass into kinetic form. When it partially does this, as in lifting the cylinder, the steam necessarily expands, and the tension of this pressure force is diminished by just so much as it passes into kinetic form.

§ 387. In all these three classes of force it is evident there can be no kinetic motion, and therefore no exhibition of kinetic force, without room to move in, for kinetic motion means motion over sensible intervals of space. The very fundamental principle of pressure lies in a struggle to get space to move through or over. This is important in our present discussion.

§ 388. Now, going back to our steam-engine, let us suppose a non-conducting cylinder of any imaginable length, even up to infinitude, if you please. Any definite amount of steam let into it will lift the piston to a definite height and there stop, because the pressure-force left in the expanded steam is not sufficient to farther overcome the resistance; and this we can continue for any length of time, lifting the piston to any imaginable height; incurring, however, the consumption of an equal proportion of fuel, and passing an equal proportion of heat into the water to be disguised in the steam in which it will remain during all the operation. In this way we may imagine almost an infinite amount of work done.

§ 389. But this manner of using steam power would be inconvenient and impracticable, because of the extent of space required for motion continually in one direction. Therefore, in order to circumscribe and economize moving space, it is necessary to resort either to rotary or reciprocal motion. For reasons not necessary to consider here rotary steam-engines have not been found practicable. Reciprocal motion is obtained by applying the pressure first on one piston face and then on the other. If applied on both at once it would simply lock up the power. Then, simultaneously with its application on one side, it must be withdrawn from the other? But can the same force be withdrawn from one side and applied to the other?

Not practicably, and for reasons lying in the very nature of heat-pressure. Heat is the basis of the pressure, it forces the expansion of the steam against resistance; but as the volume enlarges the pressure lessens. This is the situation when the piston is driven to the top of the cylinder. The pressure of the steam is diminished by reason of its expansion, and can be restored only in one of two ways, either by re-compressing its volume or by adding more heat. It cannot be compressed back into its original volume without the expenditure of as much energy as is exerted in lifting the piston. If it could be, then it might be transferred to the other side of the piston and the same portion of steam might be made to do work endlessly.

§ 390. But as it cannot be practicably transferred to the other side of the piston it must be disposed of in some other way. If it could be done without letting in air it might be discharged into the atmosphere. But the best way has been found to condense it by cold in the condenser. This being done, steam let in from the other side drives the piston down, and that being condensed in turn it becomes necessary to let in steam from beneath once more. And this steam is water in which other heat from combustion is present. Now the question arises: The first volume of steam having given up its heat in the condenser, why may not *that* heat be made to do the same work over? Because it is too much diffused, it has spread itself out too much, it has been absorbed by too large a volume of water; so that there is no means of so reconcentrating it as to turn the water back into steam of sufficient tension to lift the piston.

§ 391. Then the theory of the Steam-Engine is this: heat is used in expanding water so as to produce a pressure on one side the piston, sufficient, by partially passing into kinetic mode, to drive the piston and its load over so much space as is considered profitably practicable, then this heat, so used, is dismissed by giving it over to cold water, and with it, of course, the remaining pressure which it supported. At the same time, other heat in expanded water comes into play on the other side, producing a like pressure, a part of which becoming kinetic, drives the piston down. The heat in this steam is disposed of in the same way, and so on continually; the main points being two: first to obtain and use, through the instrumentality of steam, heat in sufficiently concentrated form; and next to get rid of it.

§ 392. Now this long dissertation on the Steam-Engine has been indulged as the means of more fully explaining that great principle of Heat-Pressure, which, in these pages, has sometimes been argued, and for the sake of brevity, sometimes assumed. Prof. Tait says that in the most perfect engine not more than one fourth of the heat employed can be utilized in work. That is he would have one-fourth the heat metamorphosed into kinetic motion and the balance returned to the condenser. For he says, in another place, that if the steam from the cylinder be blown into the condenser without having done work, it will give up more heat than if it is forced in after having lifted the piston. It is not intended to repeat, *contra*, the arguments heretofore urged, but simply to call attention to one or two considerations. If Prof. Tait is right, and one-fourth or any other part of the heat which supports the pressure of the steam has metamorphosed into kinetic motion, then the steam which has done the work in such case *should have one-fourth less pressure than the same volume of steam at the same temperature let into the cylinder without doing work.* Heat is the basis or cause of the pressure; in proportion as that basis is withdrawn the pressure should cease.

§ 393. Not only so, but on that hypothesis a less power than was expended in raising the piston should be needed in compressing the steam again. Suppose one-fourth the pressure expended in lifting the piston half way up, then an equal amount of steam at the same temperature let in above would have a third more tension, and, if our cylinder should be, say 28 inches, would force this piston back, so that we should have 12 inches of steam below and 16 above at the same temperature, and of the same weight or quantity, exerting equal tensions, because the first has already given up one-fourth of the basis of its pressure.

§ 394. But on the theory that heat is merely the basis or support of the pressure which continually grows up out of it, struggling to pass into kinetic form, and doing work as pressure, simply, until occasion occurs where it can, by overcoming resistance, pass into such form and produce kinetic motion, all difficulty vanishes, save one, the origin of this continually growing up Pressure-force. But this we can no more solve than we can the origin of the constantly growing up Gravity in all matter; or of Cohesion, or Elasticity against resistance. All we do know is that physical nature is inexplicable without the assumption that these .forces do unceasingly grow up or become manifested from some source underneath or outside of what we know of physical nature, and that their prior history and genesis are utterly untraceable. And we know that this contradicts Conservation.

CHAPTER XIX.

CORRELATION OF PHYSICAL FORCES WITH THOUGHT AND MIND—THOUGHT AND FEELING ONLY METAMORPHOSED FORCES—SPENCER—INTELLIGENCE—KNOWING—CONSCIOUSNESS AND OBSERVATION—LAW—ATOMIC MOTION—PLANETARY MOTION—CRYSTALLIZATION—MECHANICAL GROUPING OF FORCES—THE WATCH—FORCES OF PLANT LIFE—FORCES OF ANIMAL LIFE—CONSCIOUSNESS—ANIMAL INTELLIGENCE BILATERAL—MENTAL PHENOMENA—VOLITION—PERSONALITY—LIFE PROCESSES—CORRELATION OF FORCE AND THOUGHT.

Force and Thought Correlated.

§ 395. Evolutionists intent, on leaving no place or room for any power outside of material nature, pretend to trace the correlation of forces to thought feeling, and volition, and even to make the soul itself a metamorphosis of sun heat and other simple forces.

Prof. Haeckel says: "Just as peculiar characteristic features of man—pride, ambition, frivolity, etc.

—are transmitted to the descendants strictly by inheritance, so, too, are the peculiar abnormal manifestations of mental activity, which are usually called fixed ideas, despondency, imbecility, and generally diseases of the mind. This distinctly and irrefragably shows that the soul of man, just as the soul of animals, is a purely mechanical activity, the sum of the molecular phenomena of motion in the particles of the brain, and that it is transmitted by inheritance, together with its substratum, just as every other quality of the body is materially transmitted by propagation."—*History of Creation*, vol. 1, p. 179. Again: "Our whole intellectual life is but the sum of the results of nerve-cells or mind-cells."—*Evolution of Man*, vol. 1, p. 129.

In First Principles, page 217, Herbert Spencer says: "Various classes of facts thus unite to prove that the law of metamorphosis which holds amongst the physical forces, holds equally between them and mental forces. Those modes of the unknowable which we call motion, heat, light, chemical affinity, &c., are alike transformable into each other, and into those modes of the unknowable which we distinguish as sensation, emotion, thought; these in their turns, being directly or indirectly retransformable into the original shapes. That no idea or feeling arises, save as a result of some physical force expended in producing it, is fast becoming a common-place in science; and whoever duly weighs the evidence will see that nothing but an overwhelming bias in favor of a preconceived theory, can explain its non-acceptance. How this metamorphosis takes place—how a force existing as motion, heat, or light, can become a mode of consciousness—how it is possible for aerial vibrations to generate the sensations we call sound, or for the forces liberated by chemical changes in the brain to give rise to emotion—these are mysteries which it is impossible to fathom. But they are not profounder mysteries than the transformations of the physical forces into each other. They are not more completely beyond our comprehension than the natures of Mind and Matter. They have simply the same insolubility as all other ultimate questions. We can learn nothing more than that here is one of the uniformities in the order of phenomena."

The argument leading to this Conclusion is too long for quotation, but it is this, in short, that every mental effort, thought, feeling, or volition, is accompanied by chemical and other changes and motions, in blood and brain, and bears a definite relation thereto; that is, that such mental action results upon the expenditure of definite portions of physical energy.

Mind—That which knows.

§ 396. This conclusion is the acme of Conservation —beyond measure of more profound interest and importance than all that goes before and leads up to it; for, if all the processes of mind are but correlations of physical forces, mind itself becomes an intangible shadow; or, as Haeckel puts it, a mechanical activity. Therefore is it that our severest scrutiny is challenged by the proposition, and it becomes necessary that we ascertain as nearly as possible what mind is and what is the origin of its processes.

§ 397. Then what is mind? The first and most obvious definition which presents itself is, *it is that which knows*. But then arises the inquiry: What is knowing? To this the answer is obvious—knowing is having knowledge. Then mind is that which has knowledge. But a further question arises: How can we know or distinguish that which knows? The answer to this query is two-fold. You know your own knowledge through the faculty of consciousness or apperception, but you cannot in that way become cognizant of *my* knowing. How then do you arrive at the conclusion that I know? By observing the way I behave, that I recognize things, that I act on certain lines of conduct, that there is system or rule in the way I comport myself. But the like facts which show that I know will show that anybody else or anything else knows. If any particular object acts on a certain line or rule of conduct you conclude that it knows to do so just as you arrived at the like opinion from my behavior.

Take an illustration: an unsupported weight always falls to the ground; therefore you conclude that the weight or something in or controlling it knows to do so when unsupported; that it distinguishes or recognizes that line of conduct as the proper one for it. We call that which makes it fall gravity; therefore we conclude that gravity, or something controlling gravity, knows so much because it behaves in that way.

Law.

§ 398. And here we may pause to catch a glimpse of the meaning of the term LAW. It is a Law that the unsupported weight shall fall—a law of gravity we call it—that is, it is the way or rule by which gravity always acts, and as we have just seen, it so acts because it, or something controlling it, knows to do that way. Then the notion which we call Law has its roots in the deeper principle of knowing, of mind. There is no law to the lunatic, because he does not know to do, to obey. So there would be no law in nature to a force that did not know to do. But we know of no physical force which does not follow some rule of action, that is, obey some law, and which, therefore, does not either know or rest in the control of some power which knows for it, to act in some particular way.

Atomic Motions.

It has been shown, §§ 175, 176, that in any atom of matter, there are, in the minutest periods of time, almost infinite gravitative pullings or tendencies to motion and that the actual motion is composited from all these tendencies. Therefore, the gravity in such atom or something guiding it knows these tendencies and how to composite them into a single line of conduct. It or something controlling it has mind to that extent, and the law of its conduct grows out of this knowing to do that way.

§ 399. Now let us suppose two contiguous but independent atoms. They are acted upon by similar but not identical tendencies, and therefore, the composition of each into motion will be different and independent, each pursuing its own path regardless of the other. In or controlling each there is a little piece of independent knowing which is liable to run counter to the other. But they may each be inhabited by other forces which will draw them together and cause them to coalesce, because that is the way they know to do. After this the separate gravitative tendencies of the two atoms have to composite into a common motion, and, therefore, in addition to the separate knowing how to do there arises a common knowing how, a *consensus* between them. And we may conceive these coalesced atoms being very numerous—numerous enough to form a planet, and then we have a *consensus* composited of all of them knowing to carry the planet around on its axis and about the sun in its orbit, while each individual retains its own tendencies to motion.

Crystallization.

§ 400. Not only so, but at the same time that the gravitative forces are compositing in the production of these tremendous motions, we may see other individual forces in the atoms knowing to come together on certain geometrical lines, making symmetrical bodies of wonderful beauty, called crystals. In crystallization each atom knows its place and takes it, as has been said, "like soldiers in a drill." The crystallizing force in the atom is always ready to act when it knows the conditions are favorable for its particular symmetrical arrangement, so it can take its appropriate place in the ranks. But it is not seen that there is a higher *consensus* of the *knowing* of crystallization as there is of gravity. All the atoms of a crystal do not seem to be commanded and controlled by a higher composited outgrowth of the individual crystallizing forces as are the planets by the composited gravitative force which sweeps them around the sun.

Chaotic Forces.

§ 401. And in contrast to crystallization we may observe the wild forces of the tornado, the explosion, or the volcano, when, although acting from the same source or origin and seemingly at first with a *consensus*, they immediately separate, each portion animating a different atom or particle on an independent line, regardless of all the others, because knowing only how so to do, with the result of leaving confusion and chaos in their wake. In the crystal there is system, order, and harmony, because the forces inhabiting the individual atoms know to take their assigned places under a law rooted down in that knowing. But in the explosion there is wreck and ruin because the explosive forces break into fragments, each independent and disregardful of all the others; because only knowing so much, and only carrying so much of law, severally with them as corresponds with and is rooted in that small degree of knowing.

Mechanical Grouping of Forces.

§ 402. But we may notice still a different phase of force-working. Examine a watch, for instance. You find different forces there acting upon different pieces of material but all on a plan and to an end. The elastic force of the main-spring is balanced by the cohesive forces of various pivots, pinions, wheels, etc., so as to get a regular and systematic movement of the hands. All the forces of all the parts are adjusted and coordinated to produce the one certain result.

Now, here, several things may be observed. In the first place each of the many pieces of which the watch is composed fills its place and does its work without any regard for or relation to any other part. The elasticity of the main-spring pulls, for instance, just as it would if wound up tight in any other place or connection. So the cohesive forces in the pivots resist the pulls just as they would any other pulls of like strength in any other place. Each force does its particular work because it knows to do it, not in that particular place only, but in any place. It is simply a collection of independent forces made to coordinate and balance.

In the next place the pieces of the watch did not move themselves into place, did not arrange and coordinate themselves. Obviously some higher intelligence planned, and arranged, and brought those independent parts together, and set them in harmonious opposition. Not only so, but as the elastic force in the spring continually struggles for relaxation, the hand of some higher coordinating intelligence has to keep it wound up.

Forces of Plant Life.

§ 403. Another illustration. A seed is covered in the warm moist earth; it swells, it sprouts, it grows, it becomes a tree. Now let the process be analyzed. What is it? Particles are taken from earth and air, and taken to pieces, and new molecules formed and put in their several appropriate places to form root, and stem, and bark, and leaf, and flower, and fruit, and oil, sugar and gum, and a hundred other vegetable products. In these processes all the physical forces of nature are in turn utilized or neutralized as need may be, controlled and coordinated; gravity, cohesion, heat, light, chemism, capillary—each is made to do service and each balanced and held in abeyance by the others; and this all on system and according to plan, so that the material particles are so placed as to form an organized individual with coordinate and reciprocal parts.

§ 404. Now let it be observed that we do not here have a higher *consensus* of a group of like forces as in planetary motion; nor each atom or molecule moving into place by reason of a force within it like that in each neighboring force, as is seen in crystallization; nor yet a fashioning, placing and adjusting of each piece or particle so that the contained forces will co-ordinate, by an outside intelligence, as in the watch. But what we do have is a co-ordinating principle within the organic individual itself, which holds, commands, controls, and adjusts the various natural forces, so as to compel them to so behave themselves as to build the giant of the forest out of raw air and earth. This principle we call LIFE.

§ 405. The characteristics of Life which may be noted here are first that it knows—this we learn from the way it behaves itself and by what it does, just as we learn that the man who made the watch is intelligent; and next, that it commands, directs and controls forces, as much so as the man who makes and winds the watch, controls forces.

Animal Life Forces.

§ 406. But there is still another form of co-ordinated forces. Here is a human being growing up from earliest infancy to mature manhood. And what are the processes? The body in all its intricate parts and complicated functions is built up of food, drink and air. In appropriating, utilizing, and adjusting these elements in the architecture of the body, the natural forces are used, controlled, balanced, and co-ordinated as in the plant; and this, too, by an interior knowing principle which we call LIFE.

How is this known? Just as the same fact is known in the plant and in no other way. What you know of the physiological processes within your own body you know by observation, just as you know of any other man's body, or of the tree. In each case Life knows how to do because it does. This you know because you see it *do*.

Consciousness.

§ 407. But in the animal there is more than this. Not only does a man digest, and assimilate, and pump his blood through lungs and body, and grow; all of which he learns only by experimental observation; but he knows, and knows that he knows; he feels and knows that he feels; he wills and knows that he wills; he remembers and knows that he remembers. And this is consciousness; it is a duplication; another side to man which the plant does not have; he is bilateral; he has a vegetal side of whose processes he has no direct knowledge whatever, and a conscious side of being of all of whose behavior he takes direct cognizance because it is as open to him as daylight. His Life is a principle of double intelligence, one half conscious and the other unconscious.

Intelligence Bi-lateral.

§ 408. But the mystery is much deeper than this. One of the great functional organs of the body, built up by Life through unconscious processes, is the brain and nervous system; and this functional organism is a necessary instrument by the use of which all Life's processes, both unconscious and conscious are accomplished. It is used in every physiological action, even in its own building and repair, as well as in all conscious processes. Thus, Life working on the unconscious side, fabricates this great instrumentality while using it, and uses it in the fabrication of itself, as well as of all other anatomical organs, and in all physiological action; and at the same time, working on the conscious side, it uses it in all thought, emotion, and volition.

And all this is done by directing and controlling most delicately balanced physical forces in such forms as heat, electricity, cohesion, chemism, etc. At the same time the conscious side of Life is the purveyor of the animal being. It has to supply food, and drink, and other necessary conditions for the unconscious side to work upon. But this it does and can do only through the unconscious use of the nervous system by the unconscious side.

§ 409. Man is then, a self-formed being, built up by the unconscious Life principle within, which, through the instrumentality of brain and nerve, subordinates, controls, and coordinates all the necessary physical forces; and not only so, but fabricates windows of the soul, windows looking outward upon the physical world, and windows looking inward upon the deportment of the soul itself, and through the same instrumentalities looks both outward and inward.

Mental Phenomena.

§ 410. The knowledge of the conscious side of life comes from four sources. 1. Sensations. 2. The conditions, forms or moulds in which sensations are cast or projected, such as Space, Time, Form and Number. 3. Certain communications from the unconscious side—pain, pleasure or appetite. 4. Apperceptions, or the direct introspection of its own workshop and processes. These pieces of knowledge, separately, or variously associated and blended, are the fundamental elements of conscious intelligence, and we call them ideas, concepts, or notions. They may be considered as mental pictures.

And all these pictures may be assorted, readjusted, formed into new combinations as enlarged pictures, and compared. If the new pictures or notions so formed are regarded simply as what *may be*, the process and result is Imagination. If regarded as what *is*, it is the basis of Reason; and the inferences from the comparisons are a kind of higher concepts or pictures, *the conclusions of Reason itself.*

And these pictures may be recalled again and again. This is Memory.

§ 411. Towards these higher or enlarged pictures the conscious intelligence may be affected, may be attracted or repulsed. And these affections we call emotions, passions or feelings. And as the conscious side may experience pain or pleasure as the gift and voice of the unconscious, so may it enjoy pleasure, or experience pain from the contemplation of the pictures of Reason or Imagination.

§ 412. And out of these, the affections, and the experiences of pleasure and pain, arises another conscious process, Desire, which may be defined as a feeling towards attaining or avoiding some end pictured in the mental gallery. And of the same class and near of kin is another order of affections, known as Motives. These are both the felt promptings to act towards the attainment of desire and the reason entertained for such act.

§ 413. And still nearer of kin is a feeling which approves or disapproves the promptings to action. This we know as conscience.

All these conditions are states or processes of the conscious side of life, possible only through the utilization of the nervous system. Such utilization involves the movements of the molecules of brain and nerve tissue by forces, and these forces are marshaled and controled by the unconscious side of Life, often automatically, and often under the behest and direction of conscious intelligence.

§ 414. We can now enumerate the following mental states or processes: 1. Simple ideas or concepts constituting the primary units or elements of knowledge, either singly or in groupings; 2. Memory; 3. Imagination or the consideration of these parcels of knowledge as only the possible, or rather without connecting them in thought with the really existent; 4. Reason or the extraction of inferences in the comparison and relationing of concepts; 5. Physical pain or pleasure, which is a revelation from the unconscious to the conscious side on the one hand and both a recognition of such revelation and an affection towards it on the other; 6. Mental pleasure or pain which is an affection of the conscious side of Life towards some concept either of the real or the imaginary; 7. Desire, or a felt want of the conscious side to attain to or avoid some pleasurable or painful state or condition, either physical or mental; 8. Emotion, or a conscious attitude of attraction towards or repulsion from some concept of the real or imaginative; 9. Motive, which is a prompting to act relative to the satisfaction of some desire or emotion; 10. Conscience, which is the approval or disapproval of such promptings or consequent action.

Volition.

§ 415. We come next to notice and illustrate a still higher faculty of conscious Life. Conscious intelligence directs through the instrumentality of the brain; and through the same instrumentality unconscious intelligence obeys, and the concepts of yesterday are recalled to the halls of memory; another direction and another act of obedience, and diverse concepts are brought together for Reason to make comparison and inference. Other like processes, and the picture gallery of the mind is hung with all beautiful and fanciful imagery. Still another command, and the unconscious soul obeys through the same channel by causing the hand to take up the pen and indict the photographings she has obediently cast in the corridors of consciousness. This conscious directive power we call the Will, Volition. And it alone of all the faculties we have studied is dominated by no other. It dictates all conscious and much unconscious action; it is dictated to by none. True, in action it has all the prior enumerated faculties spread out before it, knowledge, reason, fancy, pleasure, pain, emotion, desire, motive and conscience; but it is shackled by none of them; it soars aloft above all; and it may choose against knowledge, against reason, against pleasure, against desire, against emotion, against conscience. True, the sane mind does not act without motive, but motive, as we have seen, § 412, is a double faculty, including both the reason for acting and the inclination to act, and reason is the inference from or a result of a comparison of concepts which is itself possible only through the directive power of the Will; so that, although Will acts from the basis of motives, still motives are in the first instance possible only through the action of Will.

So it comes to this, that the Will is the *primum mobile* of the conscious soul, the initial point of all conscious action, the uncaused cause of all conscious processes.

Personality.

§ 416. But higher still than this is one other principle, the crowning faculty of the intelligent being. This is the knowledge, uncommunicated, unaccounted for, and unaccountable, that the something which thinks, and feels, and desires, and wills, and acts, to-day, is the same something which exercised all these faculties yesterday, and the day before, and on back to the very beginning of memory. This is the knowledge of personal identity—Personality,—Self—the Ego.—" *Cogito ergo sum,*" *Descartes.*

Life-processes.

§ 417. In man, therefore, we have an intelligence which is two-sided, or double, and reciprocal; and which, through the one material organ of brain and nerves, by a double and reciprocal co-ordination, control, and adjustment of the physical forces therein, carries on all the processes of life, thought, will, and action. The forces are directed, and under direction cause movements of brain and nerve molecules, and by reason of these movements arise all the phenomena of life on both sides. That is, the life-principle, in its two states, uses the brain, by means of its control over physical forces therein, as the instrument of all its processes, just as the engineer, by means of the force of steam, uses the steam engine to do work.

Force and Thought.

§ 418. It will be noticed, also, that the knowledge of the phenomena of the two sides is obtained through diverse modes of action, that of the conscious side by apperception or consciousness, and that of the unconscious side by observation and experiment. There are no other methods of learning anything of either.

§ 419. And now to come back to Mr. Spencer's hypothesis that all these operations of mind are but metamorphoses of force, it is and can be nothing but a naked hypothesis. It cannot be proven. There is no evidence to support it. All Mr. Spencer's lengthy arguments in that direction fails of presenting any legitimate evidence upholding the contention, as will presently be seen.

§ 420. If some of these phenomena are metamorphoses of force they all must be, including the notions of time, space, will and personality. If that be true, then all we know, or can know, of personal identity, of self, is a bundle of metamorphosed forces without any substratum or principle of continuity behind it that we know or can know anything about. And as these forces come together to make *self*, they must, necessarily, in re-metamorphosing into other forms or modes, be continually unmaking and tearing down *self*. And we have no more right to predicate a principle of personality behind these transformed forces than to people the moon with whiteel ephants; for, in either case, we have reached the extreme edge of the knowable, and beyond that any one thing is as likely to be true as another. Agnosticism is not a strong enough term for this belief.

§ 421. Again these supposed identities on the two sides of the metamorphoses are of different orders of existence, as much so, as bread and time, or iron and space. On the one side is that whose only known characteristic is that it can pick up an atom or a world at A and transport it through space to B; on the other are notions, emotions, volitions, thoughts, loves, hates, and willings to act. In one place we have the actor in one mode of existence, and in the other, the results of action cast into a different mode of existence; and they are said to be identical in essence!

§ 422. And, as we have seen, the Life principle uses these forces as tools in the fabrication of all mental phenomena. But if Mr. Spencer is correct, the instruments are the same in essence as the fabrics produced, and the Actor using the instruments is made up of a continuity of the fabrics which itself manufactures. All of which seems absurd enough.

§ 423. Now let us see what takes place in the brain. Certain physical forces act, producing motion, change of place in its particles. How? As all other motion is produced, the forces entering into and moving the particles. What become of the forces after the particles are moved, the change of place accomplished? They may be neutralized by counteracting forces, or they may be communicated to contiguous teguments and walls, just as may happen to similar forces in similar masses of *dead* matter. But something else takes place coetaneously—sensations, emotions, volitions. Mr. Spencer says, a force existing as motion, heat, or light, is transformed into the thought, emotion, or volition. Now force produces or causes motion; it is not transformed into motion. Heat produces motion, but is not motion, and not metamorphosed into motion. Why shall it be said, that although a force can produce motion, without becoming motion, yet it cannot produce an emotion, thought, or volition without becoming such? Certainly there is no logical necessity for any such conclusion in either case.

But is it clear, that the action in the brain matter of chemical or other forces, produces or causes the mental action at all? Is it not logical to suppose, that, when the mind would use the brain in thinking, or willing, or feeling, it calls these forces into action, uses them for its purposes, and then dismisses them; just as when it would use the hand in writing, it summonses forces in the form of muscular contractions and relaxations, and puts them to work, and keeps them at it until it is done with them or they are exhausted? In either case the amount of force used would be the measure of work done.

§ 424. But admitting Mr. Spencer's doctrine, wherein does it help the theory of Conservation of Energy? When forces are correlated into thoughts and volitions, what then? How is any further change to be gotten out of them, any other mode of force to be extracted from them? Can a desire act on matter, take hold of it, and whirl it into motion? Can a thought make a top spin, or violin string vibrate? Clearly not, because the mind cannot grasp the conception of a thought, a mere particle of knowledge, going out, entering into, and driving matter through space. Therefore, if force can metamorphose into mental products, it is to be forever lost *as* force. But how is this answered? By giving to thought a kind of virtual power; by saying that thoughts inspire to deeds, and in that way, reinduce action; that is to say, that figuratively, or potentially, but not actually, thought is power or force. Now science has no use for figures of speech; and whenever any theory is forced to call upon them to bridge chasms, the sooner such theory is discarded the better. But were such a course of reasoning at all allowable, still there could be no quantitative relation between the force spent in thinking, and the product of thought, because there can be no ratio between the effort of thinking and the wrought out results of the thought.

§ 425. But once more, the thought is itself impossible. It is possible to think of gold becoming bread, or milk, or meat, but not of its becoming time. So, it is impossible to think of motion becoming force, or force, motion, by a mind which has once accurately distinguished between the ideas. Equally so, it is impossible for such a mind to conceive of force, or motion either, for that matter, being converted into thought, will or feeling.

And now, I think, that it may well be replied to Mr. Spencer, that, "whoever duly weighs the evidence will see, that nothing but an overwhelming bias in favor of a preconceived theory, can explain its acceptance," to wit; the correlation of physical forces with mental phenomena. But duly weighing the evidence is the difficulty, since the words and terms used to balance it in the scales of reason, are wrongly marked and numbered.

If thought, will, and feeling, are but metamorphosed physical forces, there is no use for mind, for there is nothing for mind to do. At most it becomes a bundle of cognitions, volitions and emotions.

Prof. Bain, is a Conservationist, but I do not understand him to push the theory to the extremity that Mr. Spencer does. He does not claim, as I understand him, that physical forces produce mind, or mind products, but only that there are invariable and parallel correspondences, between nervous and cerebral action on the one hand, and mental processes on the other; that every mental action is accompanied by a definite expenditure of brain force, but not measurable by our present appliances. This, as I have shown, may all very well be, without the necessity of thinking that such expended forces metamorphose either into mind, or mind products; for it is entirely logical to suppose, that the mind, acting as a director of all the forces of the physical body, causes these cerebral actions as a means of, its own processes.

Life Principle.

§ 426. But, as has been shown, there is in all known action a principle beneath and above the action, a something that does because it knows to do, that obeys a superior law because such law is of the essence of its knowing. This principle is, as we have seen, in orbital motions, in the crystal, in the watch, and in the tree, a co-ordinating principle, a principle which brings together, adjusts and holds forces to their work. In the watch it is an extraneous principle, the intelligence first of the maker and then of the owner. But in the tree it is a native and internal principle, which has its home in the house it has builded by dominating physical forces.

In man the office and capacity of this principle is wonderfully enlarged. It not only dominates nature's forces to build a temple for its own residence, but it fabricates a wonderful instrument which it uses in temple building, and not only so, but uses in all its dominations of natural forces, and through and by means of which it uses the natural forces in making the acquaintance of the objective world. And, more than all this, it so controls the forces through the use of its wonderful selfmade instrument as to give itself another half, another side, which can look abroad into the outer world and within on its own behavior, feel pleasure and pain, love and hate, desire and aversion, and, more yet, remember and imagine, and still more, will to do or to leave undone, and most of all, know itself of yesterday to be itself of to-day.

And Mr. Spencer and Prof. Haeckel make this principle, the Life, the Personality, the Mind, the Soul of Man, but mechanical activity, a bundle of the effects of these physical forces; a correlation of the fleeting physical energies which it continuously picks up, uses, and throws aside in its wonderful achievements! The proposition seems more illogical than would the assertion that the drops of water whose momentum turns the wheel are the same in essence as the silken fabric woven in the loom driven by the wheel. For certainly no one has ever yet traced any physical force through transformations into any mind-process or mind-product, much less into mind-essence. Not even in any single instance has quantitative or numerical equivalence between these diverse orders of existence ever been established. Indeed, because they *are* diverse orders of existence, it seems impossible that there should ever, in any instance, be any such equivalence. Therefore, not only is the doctrine unproven, but seemingly impossible of proof; and not only so, but impossible of being rationally conceived by the human mind.

CHAPTER XX.

CORRELATION OF PHYSICAL AND SOCIOLOGICAL FORCES—SPENCER.

§ 427. Mr. Spencer contends that all social and political phenomena and movements are but transformations of the physical forces, of light, heat, gravitation, etc. "If the general law of transformation and equivalence holds of the forces we class as vital and mental, it must hold also of those we class as social. Whatever takes place in a society is due to organic or inorganic agencies, or to a combination of the two—results either from the undirected physical forces around, from these physical forces as directed by men, or from the forces of the men themselves. No change can occur in its organization, its mode of activity, or the effects it produces on the face of the earth, but what proceeds mediately or immediately from these."—*First Principles, p.* 318.

Sociological Forces.

"The correlation of the social with the physical forces through the intermediation of the vital ones, is however, most clearly shown in the different amounts of activity displayed by the same society according as its members are supplied with different amounts of force from the external world." *Ibid.*

"If we ask whence come these physical forces from which through the intermediation of the vital forces, the social forces arise, the reply is of course as heretofore—the solar radiations. Based as the life of a society is on animal and vegetal products; and dependent as these animal and vegetal products are on the light and heat of the sun, it follows that the changes going on in societies are effects of forces having a common origin with those producing all the other orders of changes that have been analyzed. Not only is the force expended by the horse harnessed to the plough, and by the laborer guiding it, derived from the same reservoirs as is the force of the falling cataract and the roaring hurricane; but to this same reservoir are eventually traceable those subtle and more complex manifestations of force which humanity, as socially embodied, evolves. *Ibid*, 219.

§ 428. That is to say the various physical forces being all metamorphoses of sun-heat, through the media of nerves and brain are transformed into the thoughts, emotions, and volitions of men, and these, through the media of language and other influences, acting on the nerves of sensation of other men, are transformed into other thoughts, feelings, and willings, and in this way society is moved.

Thus Mr. Spencer says: "Objections of two opposite kinds will perhaps be made to these sociological applications of the law. By some it may be said that the term force as here used, is used metaphorically—that to speak of men as *impelled* in certain directions by certain desires is a figure of speech and not the statement of a physical fact. The reply is that the foregoing illustrations are to be interpreted literally, and that the processes described *are* physical ones. The pressure of hunger is an actual force—a sensation implying some state of nervous tension; and the muscular action which the sensation prompts is really a discharge of it in the shape of bodily motion —a discharge which, on analyzing the mental acts involved, will be found to follow the lines of least resistance. Hence the motions of a society whose members are impelled by this or any other desire, are actually, and not metaphorically, to be understood in the manner shown." *Ibid*, 244.

§ 429. So he makes it the same identical *something* —first sun-force, then some other mode of force it may be, then a nervous motion or discharge, then a thought, then another nervous discharge, then an expression in language, then a wafting of the language through aerial vibrations to the ears of other men, other nervous discharges, and so on interminably. And it is not metaphorically but actually the same physical force which emanated in the sun, thus variously modified!

§ 430. Let us take an illustration: Sun forces through various modes and avenues reach the brain of an orator, are transformed into grand and burning thoughts, he goes to the senate or the rostrum, and by other nervous action, these thoughts become words, which, falling upon attentive ears again become thoughts, and now are transformed into emotions, desires, and volitions, and these into actions which agitate nations. When the orator speaks, some scribe is induced to copy his language, long afterwards someone else is moved to print it, and then in some other land it is read and a whole people are aroused to strike for liberty, governments are revolutionized and nations born. Is it not patent that there cannot possibly be any quantitative equivalence between the sun-forces acting through divers metamorphoses upon an orator's brain and the possible or even probable results of his oratory? Is it not clear that there could scarcely be a possible ratio between all the sun-forces that even thus indirectly, or, directly for that matter, animated thoughts in the minds of Confucius, Moses, Paul, Mahomet, Luther, Shakspeare, Newton, Columbus, Napoleon, or Washington, and the widespread and continuing influence of their language and actions? Yet, if Mr. Spencer is right, there must be an exact equivalence between the sun-forces which operating on the brain of Mahomet were there turned into thought and the whole resultant effect of Mohammedanism in the world to-day; and if any quantitative equivalence could be found it would be no proof of identity of essence. And contra, if a thread of identity could be traced it is not possible that there should be any quantitative equivalence, and it may be observed that all the arguments of §§ 420–426 apply in full force here.

§ 431. And now let us observe how Mr. Spencer would establish the hypothesis. He says: "Regarded as an induction, the doctrine set forth in this chapter will most likely be met by a demurrer. Many who admit that among physical phenomena at least, transformation of forces is now established, will probably say that inquiry has not yet gone far enough to enable us to predicate equivalence. And in respect of the forces classed as vital, mental and social, the evidence assigned, however little to be explained away, they will consider by no means conclusive even of transformation, much less of equivalence.

"To those who think thus, it must now, however, be pointed out, that the universal truth above illustrated under its various aspects, is a necessary corollary from the persistence of force. Setting out with the proposition that force can neither come into existence, nor cease to exist, the several foregoing general conclusions inevitably follow. Each manifestation of force can be interpreted only as the effect of some antecedent force: no matter whether it be an inorganic action, an animal movement, a thought, or a feeling. Either this must be conceded, or else it must be asserted that our successive states of consciousness are self-created. Either mental energies as well as bodily ones, are quantitatively correlated to certain energies expended in their production, and to certain other energies which they initiate; or else nothing must become something and something must become nothing. The alternatives are to deny the persistence of force, or to admit that every physical and psychical change is generated by certain antecedent forces, and that from given amounts of such forces, neither more nor less of such physical and psychical changes can result. And since the persistence of force being a datum of consciousness cannot be denied, its unavoidable corollary must be accepted." *Ibid*, 221.

Sociological Forces.

§ 432. Now this is a remarkably vicious piece of reasoning. It assumes the universality of the persistence of force, and upon this assumption holds that it must prove good in this instance of physical, psychical, and social forces. True, he says persistence of force is a datum of consciousness. But this is the assumption. He has attempted to prove by an analysis of thought-processes that the concept of persistence underlies all other conceptions; but, were his conclusions just, they could be no broader than his premises, and he does not attempt to include them in the transformation of physical into mental and social forces. If it were a datum of consciousness, as applicable to them that would be the end of argument. The doctrine of Conservation as applicable to vital, mental, and social phenomena is the very question at issue—is it true, or is it not true? Mr. Spencer says it is true because Conservation is true. In other words, the universality of Conservation has been accepted without reference to these phenomena, and now it must be applied to these, whether it fits or not, for otherwise the accepted universality fails. In precisely the same manner we have seen Dr. Mayer demonstrating that Gravity is only a quality of matter, and it is a favorite mode of argumentation with all the smaller and many of the greater lights in science to prove any valued theory. They say Conservation is true, but if so then the pet theory must be true for the contrary would stand in contradiction to the great doctrine. But Mr. Spencer is the only one noticed who attempts to establish the truth of conservation on the logical basis of *the assumed fact that Conservation is true.*

§ 433. There is another vice lurking in this assumption—the same that we have seen Judge Stallo fall into — that of accepting the "scaffolding of thought" as the realities of existence. He says the concept of persistence is the bed-rock of all thought, therefore, persistence is the universal primal factor in all existence; and, therefore, the religious notions of the Mohammedan of to-day, aye, the very polity and social condition of the Bedouin tribes of to-day, are the identical sun-forces which caused Mahomet's brain and nerves to quiver. The fallacy of this mode of reasoning does not need further discussion.

§ 434. Another fatal objection to all this hypothesis is that there can be no possible quantitative admeasurement and comparison. Time cannot be measured by nor compared with space. No more can thought, or feeling, or desire, or will, be measured by or compared with force or motion, because they are of different orders of existence, just as time and space are of different orders of existence. If any man should feel like asserting that a certain hour of time was quantitatively equivalent to and indeed had been transformed into a certain bounded space, the only disproof that would seem possible would be the utter absurdity on its face; but certainly he would be little able to bring any proof to sustain his assertion.

§ 435. And Mr. Spencer is candid enough to admit that there can be no comparison or equivalence where there can be no common unit of admeasurement found, and that there is no common unit possible here. And so, without other support or prop, he leaves the immense proposition resting wholly and solely on his other proposition, that persistence is a datum of consciousness. That is to say, he assumes that of all these moulds of thought, Time, Space, Number, Relation, etc., which the mind uses in all thinking, and without which no thinking is possible, simply because all existence about which thought can be employed is in Time and Space, is singular or plural, has relations to other objects, etc., *Persistence* is the primal and most universal basis of thought without which no other thought is possible. Granting this contention for the occasion, does it necessarily follow, that because Persistence is a necessary instrument or mould in all thinking that it must be equally as universal in existence; that, as the instrument or means of thought is, exactly so must be the objective existence thought about? It would seem that the affirmative is a pure assumption. But, granting this also, for the occasion, how yet does it prove or tend to prove that existences which to sense and reason belong to different and incomparable orders of being are in reality one in essence? only different modes of the same existence?

§ 436. Another view: If the physical forces, Heat, Light, Gravity, Cohesion, Chemism, Capillary, Elasticity, etc., are the same in essence, identity and being as thought and feeling, desire, hope, love, hate, grief, pain, pleasure, or remorse; and not only so but the same as all social movements, political and religious notions, and dogmas, etc., does it not come to this that there is and can be no distinction between things? that everything is one and one is everything? and that reasoning can be only a blind tugging at the sweep of a mud mill grinding out the very mire through which we have to wade? If, when we have recognized the broadest distinctions which mind is capable of attaining to, we are to be told there are no distinctions there,—that what seems so wide apart are not only close together, in juxtaposition, but absolutely one and the same, what further credence is reason entitled to? Certainly there should be something approaching a clear demonstration to induce a logical mind to accept such a doctrine in the teeth of the further fact that if it does not annihilate mind entirely, as Haeckel would have it, it does reduce it, most certainly, to an impersonal registering machine for the thoughts and feelings into which the various physical forces project themselves; simply to a stand-pipe into and through which these forces, in the modes or forms of thought and feeling, flow and ebb in their ceaseless rhythmic pulsing between two eternities.

CHAPTER XXI.

SPENCER'S PHILOSOPHY—BEECHER'S ESTIMATE OF IT —RECONCILIATION OF SCIENCE AND RELIGION— RELATIVITY OF THOUGHT—LAW OF THE CONDITIONED—THE ABSOLUTE.

Philosophy and Religion.

§ 437. Having discussed the basis of Mr. Spencer's philosophy of evolution and removed the very foundation of his system by disproving the universality of the doctrine of the Persistence of Force, I purpose following him into the domain of metaphysical philosophy and ascertaining whether his conclusions are equally inconclusive there. This is the more necessary because he has here formulated a philosophy of his own; not founded on any prior announced theory by other men; which, though not logical, is yet so original, broad and comprehensive, as to compel admiration, and impress, not only the scientific world, but many learned religious teachers with its verity.

Thus Mr. Beecher says of him in speaking of the English school of Evolutionists: "The ablest thinker of them all, and the ablest man that has appeared for many centuries, Herbert Spencer, seems to me to have passed the winter solstice. It seems to be a dawning spring with him, and summer should his life be spared. I should not wonder to find in him the ablest defender of the essential elements of Christianity. Not that I regard every part of his system with like favor; not that I should regard every station which he has established and position which he maintains as to be believed in. And yet, when, by and by, the bounds of knowledge are widened and the interior more perfectly surveyed and settled, I think Spencer's name will be found to have given the world more in one life-time than any other man that has lived in the school of philosophy in this world."

The establishment of the general correctness of his system of philosophy, which is intended to be universal, can alone justify this glowing encomium."

I shall, therefore, analyze and criticise the fundamental principles of his system, as laid down in First Principles, with some considerable particularity.

§ 438. In Part I. of First Principles, Mr. Spencer undertakes to find a common principle upon which all science and religion may be reconciled.

The conclusion of the argument is, that the *Absolute* transcends all knowledge and conception, and is, therefore, unknowable, except as a vague abstraction of all pervading power without attributes or relations. And as we think it, thus it must be to us. Therefore, we cannot know God as a personal Deity, giving law to man and exacting obedience from him, and, therefore, he does not so exist to and for man. The reasoning by which this conclusion is reached is twofold, having a religious and a scientific side.

The religious side of the argument is as follows: there is a basis of truth in all error. By generalizing opinions we may arrive at truths permeating whole classes of beliefs in different ages and amongst many different peoples, and the higher we may carry such generalizations, the more abstract and exact, as well as the fewer in number, will such all-pervading truths become, and with the greater reliance may they be accepted. By taking the opinions of all communities in all ages on any particular subject, eliminating therefrom all views rejected by any, and retaining such only as are accepted by all, we may reach conclusions of absolute verity. Taking thus the religions of the world, and disregarding all opinions rejected by any sect or class, we have left only a belief in an inscrutable Power without qualities or relations. This much, and only this much of religion may be accepted as true.

The scientific side of the argument is three-fold. First: all known facts may be generalized into truths fewer and fewer in number but wider and wider in application and more and more abstract in character, until we come to a few ultimate facts based upon the incomprehensible, unknown and Absolute, which are not susceptible of explanation. These ultimate facts which are known, are but representations or symbols of the Unknown, Absolute and Infinite.

Second: All knowledge is relative; knowing is relationing; thought is possible only as a relativity; *this* can be known only as differing from *that*, and *that* only as differing from *this;* where only there is actual relation can there be thought relation; and as there can be no actual relation between the finite and the Infinite, the Infinite cannot be thought save as an abstraction.

The third argument is Sir William Hamilton's doctrine of the Conditioned; that all thought lies between two unthinkable extremes. Thus, we can think neither the absolute commencement nor the eternity of time, yet we know that one or the other must be true. We can think of space as being neither absolutely bounded nor unbounded, yet we know it is one or the other. So in any direction we can think the Absolute, neither as limited nor unlimited, though it must be the one or the other. Therefore we arrive by another path at the conclusion that the Absolute is unknown and unthinkable except as an abstraction. And thus the two sides of the argument conduct us to the same conclusion; that all we may accept as religious truth turns out to be all that science can give us of the Absolute. And here science and religion meet in reconciliation.

§ 439. After this analysis of Mr. Spencer's argument, its claims to consideration may be examined. And first the religious side: That there is a soul of truth in all doctrines which may be found by eliminating therefrom all contradictory opinions, is an assumption merely, a beautiful theory it may be, but only a theory, neither an accepted fact nor demonstrated premise to serve as the basis for logical argument. Indeed, it is not seen where Mr. Spencer finds data to justify the theory even as a provisional hypothesis.

And the assumption, if sound, would annihilate every doctrine, scientific or religious to which it might be applied. For if a correct process of arriving at the *true*, it must be equally correct in arriving at the *not-true*. Arriving at truth is simply distinguishing it from error; but the process of distinguishing truth from error distinguishes, at the same time, error from truth. Therefore, if the agreement of all religions on any one proposition distinguishes it as true, their disagreement on any other proposition must distinguish it as false. Hence, while according to the argument, all there is in Protestantism that is in all other religions is distinguished as true, it must likewise result that all there is in it that is not also in Catholicism, and Mormonism, and Mohammedanism, and Brahminism is distinguished as erroneous.

Now applying this logical process to scientific opinions, it will result, that while all there is in common in the Newtonian and Copernican and Ptolemaic and Hindoo doctrines of the solar system is true, all that in which they vary must be false. And so while that in which Spencerian philosophy, and Hamiltonian philosophy, and Kantian philosophy, and Cartesian philosophy, and Platonic philosophy, all agree is distinguished as truth, that in which they contradict each other is equally distinguished as falsehood.

Thus it will be seen that no such reasoning process can be used in science or philosophy without destroying every system ever invented by man. It is not claimed—and were it claimed it could not be maintained—that any different mental faculties or logical processes are used in the investigation of the one branch of knowledge from that which is used in the other. Why, then, should it be insisted that a course of argumentation which will destroy all philosophy should be just the process best adapted to reach religious truth?

§ 440. But granting the use of this course of reasoning has Mr. Spencer applied it logically? This depends largely on the proper definition of the term *religion.* What is religion? As Mr. Spencer has not defined his use of the word, this definition may be ventured: *Religion is the relation existing between Man, Self, the Ego, and the Unknowable, Absolute, Deity.* It may be assumed that this is the central thought in every religious system. Some supposed relation in which man stands to a superior Power in nature seems to be the pivotal idea in every religion. If this be true, there are, then, at least three terms in every religion which Mr. Spencer's process will not eliminate, and which, therefore, must be verities—Deity, Man, Relationship. The existence of Man, Self, and some relationship which he bears to the unknowable, the "Inscrutable Power in Nature," are truths, then, as certain as the existence of the Unknowable Himself, and established by the same processes of reasoning. Why should these two facts be discarded and only the other accepted?

But if a relationship between the Unknowable and man is a thinkable, veritable fact, then the Unknowable is not merely an unrelated, unconditioned, abstract, inscrutable power; but a Being holding relations to the finite, to man, which may be thought and known; a personal power. Thus is there on every side logical suicide in the first branch of Mr. Spencer's argument.

Relativity of Thought.

§ 441. In discussing the scientific side of the argument the proposition that all ultimate facts of science are founded on the unknown, and are therefore unexplainable, may be admitted, for mystery underlies all knowledge. The way may be seen for a few steps, the chain may be followed for a few links only; for, in whatever direction the attempt may be made to follow facts to their ultimate causes, soon the obscurity of night settles down upon the searcher.

§ 442. But although supported by high authority and great names, the second proposition, that *all knowledge is relative* and thought possible only as a relativity cannot be so readily admitted. For, suppose a man of sound mind, retaining all other faculties to suddenly lose his memory; and then suppose a first sensation, say an acute physical pain. According to the theory, he can have no knowledge of this; because, having lost his memory, he cannot recall any former pain, nor any other sensation for that matter, with which to establish a relation or make a comparison. He feels pain, but cannot know it or think it even, because he has nothing in memory with which to connect it. Suppose he has a second like pain, he is yet in the same condition; for, as he could not know nor think the first, he has nothing in memory with which to measure the second. And so it will be with the third and every one after. As a necessary consequence he can never know or think pain at all, because he could not know a first pang. The same logic demonstrates that he can never have any knowledge nor conceptions from any of the senses, because the first thought is impossible for want of a prior thought with which to compare it.

§ 443. But the attempt is made to obviate this difficulty by resorting to the doctrine of the Conditioned. That applies, however, as will be hereafter shown, only where the mind attempts to grasp the infinite on the one side or zero on the other—altogether a different thing from the problem in hand. The fact is, that in the illustration put, there would be in the mind as perfect a concept of that first pain as of any that might ever be experienced, though he might not be able to locate it or form a notion of its cause. So the first stroke of a bell falling upon his ear will be as thinkable as after its repetition a thousand times, though of course he may not know it is a bell. A young man who, at an early age entirely lost the sense of hearing from disease, says that he has a distinct recollection of a peal of thunder heard before his affliction but has no impression whatever of any other sound. Here this single thought of its class has lived alone in his memory, occurring again and again for years, unvaried, unconnected, unrelated, because there has been nothing else in his memory with which it could stand related or be compared. Now can there be any doubt that if this young man had been born deaf, and for a single moment his ears had been opened while the peal sounded through the heavens and then closed forever, that this ever-recurring thought would not have been any less distinct than it is?

§ 444. The difficulty is that psychologists and metaphysicians have confounded distinct mental faculties, or at least, the processes of distinct faculties. *Reasoning is relationing*, reason is the faculty of comparing, weighing and measuring thoughts one with another and grasping the relationship between them. Perception is an earlier faculty, or, at least, the earlier process of faculties by which is furnished, through the media of the several senses, the raw material for reason to work upon, the sensual concepts for her to put into relationship, compare, and formulate results.

The Ego and Non-Ego.

§ 445. But it is said that necessarily all thought is either of the Ego or Non-ego, that they are correlatives unsusceptible of disconnection, and that the one cannot be thought without the other. The admission of the first part of the proposition does not carry the latter part with it. What is not the Ego must be the Non-ego, but it by no means follows that one cannot be the subject of thought unless the other is also. It is said you cannot think of self except as distinguished from or in opposition to Not-self. From what Not-self? From all the Not-self? That is impossible, because the mind cannot grasp all that is exterior to self, and indeed, in a single effort can grasp but a remarkably small portion of it. Then what part and how much of it? Must you think some other man in contradistinction to yourself? What other? Why one other rather than any other? Why another man rather than a horse, a house or a tree? Why any one thing rather than any other? If, thus, this supposed necessary thought correlative to self cannot be the Non-ego in totality, and if there is no determining reason why it should be any one object rather than any other, whence comes the necessary law of making it anything at all? The fact is, that while you *may* think of Self in contradistinction to any other object or group of objects whatever, and *may* contrast, and liken, and compare, you may, and usually do, think of it without the thought of any other object in the mind. So you may think of a house in contact with other houses, houses, trees, or self, and you may think of it without connecting them with any other objects either of the Ego or Non-ego. And the argument recurs, if it is necessary that you should think of it in connection with other objects, where is the law to determine what objects?

It is very true that we know the Ego is the Ego and the Non-ego is the Non-ego; and also, that when we undertake to answer to ourselves how we know the one is not the other we have to contrast and compare, and then they become real correlatives. But this is an effort of reason and not the necessary nor ordinary process of perceptive thought. When you think the Ego, you can by an effort think it not a tree, a flower or some other man, but you do not ordinarily do so; and when you think a tree, a flower or some other man, you can, by an effort, think it not the Ego; but you do not usually so formulate your thoughts.

The Finite and Infinite.

§ 446. If, then, it is true that perceptive thought is not a process of *relationing*, the value of Mr. Spencer's next proposition vanishes. Nevertheless, it may be examined on its own merits. He argues that only where there is actual relation can there be thought relation; that there can be no actual relation between the finite and the Infinite, and therefore the Infinite cannot be thought save as a vague abstraction. Now, if by relation is here meant quantitative ratio the proposition is correct. The number 4 bears a ratio to any definite series of 4's, but not to an infinite series. An hour of time bears a ratio to any finite number of hours, but not to eternity. Neither can any finite exhibition of Divine will, or wisdom, or power, bear a quantitative ratio to the Infinite and Absolute. But there may be other relationships than quantitative, such as those of distance and direction in space, antecedent and subsequent events in time, cause and effect, sovereign and subject. And wherein is the logical difficulty in the thought of an Infinite Sovereign ruling a finite subject or of an Infinite Cause producing a finite effect? Of course these relations cannot be thought in their totality, that is to say, on the side ofthe Infinite, the mind cannot grasp the full notion, the total of the Infinite. It only thinks so much of the Infinite as is exhibited in producing the effect.

§ 447. But this will be better understood under the next branch of the argument which is Hamilton's doctrine of the conditioned, somewhat modified, meaning in its most abstract form, that the Infinite in all directions, as well as zero, is unthinkable. And this is strictly and logically correct. To illustrate : you cannot think limitless extension in space, for that would be to think the Infinite; neither can you think any absolute bounds to space, for that would necessitate thinking the *nothing* beyond such bounds, yet you know the one or the other must be true. So you cannot think time without beginning, for that is the Infinite again, nor yet can you think such beginning, for that involves the nothingness before its commencement. Yet while neither proposition is thinkable, because the finite mind is incompetent alike to seize in thought the Infinite or *nothing*, you know that either the one or the other must be true. And so it is in every direction. All thought is a mean between the two unthinkable extremes of Zero and Infinity.

But what does all this amount to ? Why, simply to the fact that the mind can thnk only that which *is* and is *finite* and limited. And there is ever and everywhere an important qualification in that the finite is always a part of the Infinite, the limited of the limitless. To illustrate again : This hour with which I have a very intimate acquaintance is a part of that Eternity of which I cannot even form a conception in totality. The room in which I write is a concept of space easily formulated, but is only a part of that altogether unthinkable Infinite reaching beyond the stars. The numerical terms 4, 44, 444, I can readily understand, but they form but parts of a series of 4's which may be extended utterly beyond my thought-grasp to the farthest nebula and back again, and then on infinitely.

So when it is said the Infinite is unthinkable, the Infinite in its totality is meant; the Infinite not in its parts but as a whole, and that for the reason that the mind cannot grasp it, cannot subtend it, cannot measure it any more than it can zero. But finite portions of the Infinite may be grasped, measured, thought and known. And as with the Infinite in other directions so with the "Absolute," which is taken to mean the Infinite Power or Mind in the universe. It cannot be known in totality. The finite mind cannot grasp all of God. It cannot know Him as limitless nor yet set limits upon Him in any direction. But what it can do is to know Him as a thinkable mean between the two unthinkable extremes, Infinity and Nothing. It may know Him just as it knows space and time and number, in His finite manifestations and parts, as it were. It may know Him in His power and wisdom as He gives laws to winds and waters, worlds and systems, just to the extent, and with the certainty, that it knows the laws which govern winds and waters, worlds and systems. It may know Him in His goodness and mercy, just to the extent, and with the certainty that it knows the manifestations of His goodness and mercy to the children of men. The Absolute is, therefore, not known in infinite totality, but as clad in just that plenitude of will and wisdom and power exhibited in the enforcement of all the known laws of the universe; and that knowledge is just as cerain, positive, and absolute as any the mind has or can have.

§ 448. It is said that behind all this is a vague abstraction or adumbration of the Infinite? It may be granted thus far. When you think of the space in your room, it is, or at least may be, with an undefined notion that there is space outside of it which you can, but do not formulate in thought. When you hold this hour or this century in your mind, it is yet with the shadowy impression that time was before and will be after it. You may awake in the night, pass awhile in thought, and sleep again, without any knowledge of what part of the night is gone or what part is to come, yet you have a general knowledge that an unknown period has passed and an unknown period is to come. Nevertheless the hour of wakefulness is as fully and certainly known to you as if you had been awake the whole night through. So when you think of a Power governing worlds and systems, it is with a sense that this is not all of it, that it extends out and beyond all that moves worlds and controls systems. But this does not detract from the certainty and positivity of that which is consciously and finitely known. So in all knowledge of the finite. It is always bounded by an impression of the Infinite, not in its totality, but in adjoinings and adboundings, these more or less definitely defined on the adbounding side with the other gradually fading out into vacuity, the shadowy borderland of the Unknown.

It may be concluded, therefore, that Mr. Spencer has failed to show that the "Absolute" is known only as a vague and undefinable abstraction, his argument falling on either side. And if these "First Principles" which are intended as a basis for a "New System of Philosophy" are thus dissoluble in the crucible of a correct logic, what of the structure builded thereupon?

The Reconciliation.

§ 449. But anyway, what does this supposed reconciliation amount to? It is only the supposed finding of the basis of both forms of thought in the Unknowable, and it is not seen that that can be satisfactory to either Religion or Science, for it is simply saying that there can be no certitude for either, while what both wants and needs most, is certainty. But it is replied that as both are founded upon the Unknowable, certainty is possible to neither. If by certainty is meant the understanding of the essence of the first cause of all things, this is true. As has already been remarked, because the faculties of thought are not infinite, there must be a limit to knowledge; there must be on every side an Unknown and Unknowable depth of essential being, but this does not militate against the claim of certainty, so far as thought actually extends.

§ 450. Now the conflict between Religion and Science lies in this, that Religion insists on the verity of certain doctrines which Science, as commonly interpreted, says, are not true, or at least are without evidence. Therefore the only reconciliation possible is either for Religion to withdraw her dogmas or for Science to admit their truth, or at least to become agnostic, and say it does not know anything about them. Religion can never become agnostic. The very terms Religion and Agnosticism are contraries. Religion must in its nature be positive, must in its essence be dogmatic. It must postulate Deity and a divine government for nature and man. Doubting these is abandoning Religion. If Science attacks these, either Religion must defend them or suicide with the blade of a timid skepticism. If in conflict, both cannot be true. If the religionist believes in the truth of his doctrine, consistency as well as honesty will compel him to ward off assaults as best he can. The scientist may honestly be agnostic. As he reads the book of Nature he may see no room for the government or even the existence of a God. But while he thus reads, it sounds childish to talk about reconciliation. That can come only by one of two processes. Either the Religionist must come to see there is not a Divine Mind in nature, or the Scientist must come to see that there is. It amounts to nothing to show, conceding for the argument that Mr. Spencer has shown, that there is a basic principle underneath all philosophy and all faith in which both the Religionist and the Agnostic believe. There may be ten thousand facts in science and philosophy, and tenets of faith in which they agree. But all this brings them no nearer together on the vital questions of faith on which they do not agree.

It is not seen that either the philosopher or the theologian is helping the matter any by crying peace where there is no peace, by setting up a memorial of reconciliation here or there when there is no reconciliation. What is needed is Truth; let every one dig for it, go to the bottom of the well and bring it up as he finds it, and be loyal to it as he understands it. And in the end Truth will prevail. If God reigns, men, even Scientists, will come to know it, concede it, rejoice in it. If the "unpitying drift of nature" drags, Religionists will come to know it, with sorrow concede it, and fling their withered hopes and bleeding hearts in its pathway.

Spencer's Philosophy.

§ 451. In the Second Chapter of the Second Part of "First Principles," Mr. Spencer lays down the following as the postulates which must be assumed to build a system of philosophy upon:

1. An unknowable power.

2. Knowable likenesses and differences between the manifestations of such power.

3. The resulting segregation of such manifestations into subject and object.

The argument by which he reaches this conclusion is as follows:

1. Every thought involves a whole system of thoughts, and ceases to exist if severed from its various correlations.

2. The developed intelligence is framed upon certain organized and consolidated conceptions of which it cannot divest itself, and which it can no more stir without using than the body can stir without limbs. Those which are vital, or cannot be severed from the others without mental dissolution, must be assumed as true, provisionally, to be justified by results, that is, by showing their congruity with all other beliefs.

3. The consciousness of congruities and incongruities, of the existence of likenesses and differences, is a primordial conception without which thought is impossible.

4. But not only must some process of thought, but some product of thought, be assumed as a substantive proposition; and this must be the one presenting the widest and most profound distinction which things present.

5. All things known to us are manifestations of the Unknowable, and these manifestations are divisable into two classes, distinguished as being vivid and faint, and which run in parallel currents, having many similarities and many clearly-defined distinctions.

6. Under the class of vivid manifestations, are to be found sensations and perceptions; and faint manifestations include emotions, with the reproduction of memory, and imagination. The former division corresponds to the *objective, or non-ego*, and the latter to the *subjective, or ego.*

§ 452. It has already been shown that thought is not necessarily relative, but that it is so used in the process of reasoning, in which things are compared, likened and contrasted with each other. Every thought, therefore, does not necessarily involve a whole system of thought, else, as there shown, the first thought would be impossible for want of a correlative, and so would be the second, and the third, and the fourth. And, therefore, no thought ceases to exist upon being dissevered from its correlations.

§ 453. I do not profess to understand just what Mr. Spencer means by "developed intelligence," and "organized and consolidated conceptions," nor do I understand how the mind can divest itself of any conception, organized, consolidated or otherwise, which it has ever once formed. And I deny that intelligence, whether by that term he intends the mind itself, or its whole circle of concepts, is framed upon certain conceptions, organized, consolidated, or otherwise. Neither the mind nor its thought products are builded upon any particular conceptions any more than is a house, or its furnishing, builded upon certain pieces of upholstery, or on certain parlor sets. If intelligence is used as a synonym for mind, then conceptions are its products; if used to denote the whole circle of knowledge possessed by the mind, then conceptions, organized or otherwise, are a part of itself; individuals out of the whole bundle of thoughts constituting the mind. But, if the author means to say that there are certain processes, or conditions without which thought is impossible, I readily concede it; but in doing so I do not concede that there is any particular process or condition necessary to *all* thought. The thought of a bird or a stone is possible under certain conditions only, and so is the thought of willing or loving, but the necessary conditions of the former are altogether different from those of the latter.

§ 454. The consciousness of congruities and incongruities is not a primordial conception without which thought is impossible, for, before such a conception can be formulated, it is necessary that the mind shall have at least four other conceptions, two of things alike and two of things unlike. The truth is, that these conceptions of congruities and incongruities are products of the reasoning faculty, for they imply comparison, which marks the essential distinction of that faculty, and reason presupposes memory, while memory presupposes thought.

§ 454. Mr. Spencer's grouping of mental phenomena into vivid and faint manifestations is defective, because it marks no clearly defined logical distinction. But, worse than this, it is incomplete. He does not give volitions a place unless he intends to include them in the emotions which would be a very illogical classification indeed. But there is one very important group of mental processes, *apperceptions*, which he certainly omits. They certainly cannot be included in sensations, emotions, memory or imagination. A system of philosophy founded on a classification so imperfect is subject to grave suspicion to begin with.

Self and Not-Self.

§ 455. But passing this, Mr. Spencer finds in his faint manifestations the Ego, and in the vivid class the Non-ego. Now the original sensational thought of a tree, no more represents the Non-ego than does the same thought reproduced in memory, imagination, or dream. On the other hand there is no more of the Ego in the representation than in the original. No distinction between the Ego and Non-ego can be found here. On the contrary, the Ego can be known only through that faculty which Mr. Spencer has entirely ignored and dropped from his classification—*the apperceptive faculty*, the conscious knowledge of the mind's own activities. You may see, or hear, or love, or hate, or will, or remember, or imagine, without once thinking of self. All these processes are possible without once presenting the *ego*. But when you formulate the thought of *doing* any of these acts, you necessarily think *self*—necessarily evoke the *ego*. Thus you may will to do a thing without formulating the thought of willing; and so you may feel, or see, or remember, or dream, without the thought or concept of so doing arising in your mind, and therefore without any *thought presentation* of the *ego*. But on the other hand, you may think of willing, or seeing, or feeling, or remembering, or dreaming, that is, you may consciously look in upon your mind while engaged in these processes, and observe, and know what it is doing; and, in doing so, you necessarily think and know the *ego*. Again, whatever you construe in thought, whether original or reproduced, which is not the process of thus looking in upon the mind at its work-bench, you think and know as the *non-ego*, and this whether you call the *ego* up in thought and contrast and compare them or not. And these are necessary formulas and conditions of thought. Looking in upon the soul in its varied employments, you see and know the *ego*, and this whether the apperception be original, or reproduced in memory, or imagination, or dream. Looking outward, through the senses, you as necessarily see and know the *non-ego*, and that whether the thought be original or reproduced. And in no other way can either the *ego* or *non-ego* be established. This is the ultimate of the proposition. Here is Consciousness on her throne formulating her highest deliverances, and to doubt these is not only impossible, but, if possible, would be destructive of all belief. Hence the formula propounded by Des Cartes, "I think, therefore, I am," is strictly and logically correct.

Therefore the *ego* is not to be found in Mr. Spencer's formula at all, but only in a class of mental processes entirely overlooked by him; and his argument fails to establish the postulates from which he educes the basis of his philosophy.

The conclusion from the above exemplification of the doctrine of the *ego* being that we are forced to accept the testimony of consciousness as an ultimate arbitrament of the question, renders it impossible for us to accept Mr. Spencer's proposition that "all things known to us are manifestations of the Unknowable," for consciousness in testifying to the *ego* testifies against the proposition. In testifying that you are an individual, thinking, willing, feeling, acting *personality*, it testifies that you are not simply a manifestation of the Unknowable.

But what does the proposition embrace? All things known to you, the material world, nature and her forces, all other men and animals, space and time, your own body, your thoughts, your seeing, your willing, your hating, your remembering, your doing, yourself, the *ego,* are each and all but manifestations of the Infinite Power of the universe. Pantheism could not be more complete. But consciousness in clearly demarking between the *ego*, with its faculties and activities, and the *non-ego*, testifies to the contrary, and her testimony is final.

The Real.

§ 456. In Chapter 3, Part 2, ***First Principles***, Mr. Spencer undertakes to define reality. He says: "By reality we mean persistence in consciousness: a persistence that is either unconditional, as our consciousness of space, or that is conditional, as the consciousness of a body while grasping it. The real, as we conceive it, is distinguished solely by the test of persistence; for by this test we separate it from what we call the unreal." *P.* 160.

There are two senses in which the real may be understood, the genuine, as distinguished from the simulated; and the existent, as opposed to the fancied or non-existent. It is presumable that Mr. Spencer uses it in the latter sense. But in the use of the term consciousness he is not so fortunate. It has been shown that consciousness is the state of the mind taking cognizance of its own operations, looking in upon itself engaged in its own work-shop. But this cannot be Mr. Spencer's meaning here. On the contrary he must mean the formulas of thought fabricated in the mind and variously called ideas, notions, conceptions, etc. Evidently what he means to say is, that the test of reality is the persistence or non-persistence of the idea or notion of the thing in the mind, for he puts this example: "Between a person standing before us, and the idea of such a person, we discriminate by our ability to expel the idea from consciousness, and our inability while looking at him, to expel the person from consciousness." *P.* 160.

§ 457. Having ascertained Mr. Spencer's meaning we are still not prepared to go forward until we have eliminated certain obscurities of expression in the illustration just quoted. Whether a person, the subject of thought, is standing before us or is absent, he can be mentally considered, grasped or thought of, only through the media of ideas, notions or conceptions of him, formed in the mind; wherefore it is entirely inaccurate to speak of comparing a ***person*** present with the *idea* of the person absent, or present, for that matter. What may be done is to compare or discriminate between the ideas or notions of the person present, or absent. Without a doubt Mr. Spencer here intends to say that while a person is standing in our presence, and we are looking at him, we cannot expel the idea or notion of him from the mind, but when he is absent we can, and by this difference of mental capacity in the two instances we discriminate the real presence of the person from his ideal or fancied presence. But the argument fails at both ends. We can expel the idea of the one from the mind as readily as the other, and whether we do so or not it furnishes no test of reality.

The fact is that it is by the exercise of the reasoning faculty that the real and unreal are discriminated. If you are expecting a visit from a friend and in idea see him before you, your reason tells you it is really he; but if you know him to be at the time in a foreign land, although the idea may be equally clear and equally hard to banish from the mind, your reason will tell you, nevertheless, that it is an illusion, dream, or fancy. And so in all other instances which may be put, persistence has nothing to do with it, reason everything.

§ 458. Proceeding from the proposition just disposed of, Mr. Spencer repeats two others already discussed and refuted, to wit, that all thought is necessarily by relations, and that there can be no thought of the Absolute because it can stand in no relationship to the finite. And on this basis he argues that all our notions of Space, Time, Matter and Motion are simply relations, "relative realities," he calls them; that the "experiences from which these notions arise are experiences of Force;" and, further, that these "relative realities" answer or are correlated to some unknown and unknowable absolute reallty. But as there is no basis to the argument it is not necessary to follow it out in all its details.

Force the Ultimate of Existence.

"We come down then, finally, to Force, as the ultimate of ultimates. Though Space, Time, Matter, and Motion, are apparently all necessary data of intelligence, yet a psychological analysis (here indicated only in rude outline) shows us that these are either built up of, or abstracted from, experiences of Force. Matter and Motion, as we know them, are differently conditioned manifestations of Force, Space and Time, as we know them, are disclosed along with these different manifestations of Force as the conditions under which they are presented. Matter and Motion are concretes built up from the *contents* of various mental relations; while Space and Time are abstracts of the forms of these various relations." *P.* 169.

The argument by which he leads up to this conclusion is that we know Matter only as resisting Force, Motion only as yielding to Force and Space, and Time only as containing Matter and Motion. But this is only arguing as we have seen Judge Stallo doing, by taking "the scaffolding of thought" as the reality towards which it leads. That we only know Matter as resisting Force as manifested in the sense of touch, is not a valid argument in favor of the proposition that it is in reality dependent upon or subsidiary to Force. The mind recognizes the outward world only by means of instrumentalities. Force is the medium through which it is enabled to recognize Matter, but it does not follow that, therefore, Matter is but a mode of Force. Motion is the yielding of Matter to Force, without Force there could be no Motion, but this does not render Motion any less real than Force; without Matter, there could be no Motion, but this does not render it any less real than Matter.

And so with Space and Time: admit that they are not cognizable save through the media of Force, this does not show them any less real, any less necessary, any less independent existences than Force. So that the argument that "Force is the ultimate of ultimates" and all other forms of existence dependent upon it fails in the analysis.

§ 459. Descanting on the Indestructibility of Matter Mr. Spencer says: "Our inability to conceive Matter becoming non-existent is immediately consequent on the nature of thought. Thought consists in the establishment of relations. There can be no relation established, and therefore no thought framed, when one of the related terms is absent from consciousness. Hence it is impossible to think of something becoming nothing, for the same reason that it is impossible to think of nothing becoming something—the reason, namely, that nothing cannot become an object of consciousness." *P.* 187.

The last sentence is correct, the mind cannot think, cannot grasp nothing, zero, at all; and, therefore, cannot think something passing into nothing or nothing into something. But as thinking is not relationing, the inability is not because of the failure of one term of a relation, and therefore, the first part of the paragraph is erroneous.

§ 460. "That, however, which it most concerns us here to observe, is the nature of the perceptions by which the permanence of Matter is perpetually illustrated to us. These perceptions under all their forms amount simply to this—that the *force* which a given quantity of Matter exercises, remains always the same. This is the proof on which common-sense and exact science alike rely.

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"Thus, then, by the Indestructibility of Matter, we really mean the indestructibility of the *force* with which Matter affects us. As we become conscious of Matter only through that resistance which it opposes to our muscular energy, so do we become conscious of the permanence of Matter only through the permanence of this resistance." *P.* 178.

Here are two fallacies, one that Matter exercises *force* at all, and the other the old one of interpreting "the scaffolding of thought" as the essence of the thought subject. Besides it is a shifting of position. On the last page Mr. Spencer derived the idea of the permanence of Matter from the inability of the mind to construe *nothing* in thought; here he derives it from the Conservation of Force.

§ 461. From this hasty review of this part of Mr Spencer's system it is believed that it is safe to say his metaphysics is not logical, his philosophy is not philosophical, his conclusions are not irrecusable. There seems to be needed a surer base, a more solid foundation, than is here presented, for one to stand upon while engaged in upturning and revolutionizing the thought and the faith of the intelligent world.

CHAPTER XXII.

ARGUMENTS STATED AND AMPLIFIED—CONTINUITY OF MOTION—PERSISTENCE OF RELATIONS AMONG FORCES—TRANSFORMATION AND EQUIVALENCE—DIRECTION OF MOTION—RHYTHM OF MOTION—INSTABILITY OF THE HOMOGENEOUS,—MULTIPLICATION OF EFFECTS—SEGREGATION,—EQUILIBRATION—DISSOLUTION.

Spencer's Physics.

§ 462. Mr. Spencer's doctrine on Direction of Motion, Rhythm of Motion, Instability of the Homogeneous, Multiplication of Effects, Segregation and Equilibration are all only expansions and modifications of the doctrine of the Parallelogram of Forces. This includes and covers all the others, but it is not seen how it accounts for the material universe. And as we have seen, in every possible composition of forces, there is a greater or less dissipation of forces, an untraceable loss of forces. Mr. Spencer says there is no such thing in nature as the action of a simple single force; then there is no action without dissipation of force.

Counter-Action of Forces.

Mr. Spencer says, "We cannot decide between the alternate suppositions that phenomena are due to the variously-conditioned workings of a single force, and that they are due to the conflict of two forces. * * * * * And, however verbally intelligible may be the proposition that pressure and tension everywhere coexist, yet we cannot truly represent to ourselves one ultimate unit of matter as drawing another while resisting it.

"Nevertheless this last belief is one which we are compelled to entertain. Matter cannot be conceived except as manifesting forces of attraction and repulsion. * * * * we are obliged to think of all objects as made up of parts that attract and repel each other." *First Prin.*, p 223, 224.

And, again: "From universally coexistent forces of attraction and repulsion there result certain laws of direction of all movement. Where attractive forces alone are concerned, or rather are alone appreciable, movement takes place in the line of their resultant; which may, in a sense, be called the line of greatest traction. Where repulsive forces alone are concerned, or rather are alone appreciable, movement takes place along their resultant, which is usually known as the line of least resistance. And where both attractive and repulsive forces are concerned, or are appreciable, movement takes place along the resultant of all the tractions and resistances. Strictly speaking, this last is the sole law; since, by the hypothesis, both forces are everywhere in action. But very frequently the one kind of force is so immensely in excess that the effect of the other kind may be left out of consideration. Practically, we may say that a body falling to the earth follows the line of greatest traction; since, though the resistance of the air must, if the body be irregular, cause some divergence from this line (quite perceptible with feathers and leaves), yet ordinarily the divergence is so slight that we may omit it. In the same manner, though the course taken by steam from an exploding boiler, differs somewhat from that which it would take were gravitation out of the question: yet, as gravitation effects its course infinitesimally, we are justified in asserting that the escaping steam follows the line of least resistance. Motion, then, we may say, always follows the lines of greatest traction, or the line of least resistance, or the resultant of the two; bearing in mind that, though the last is alones trictly true, the others are in many cases sufficiently near the truth for practical purposes.

"Movement set up in any direction is itself a cause of further movement in that direction, since it is the embodiment of a surplus force in that direction. This holds equally with the transit of matter through space, the transit of matter through matter, and the transit through matter of any kind of vibration. In the case of matter moving through space, this principle is expressed in the law of inertia—a law on which the calculations of physical astronomy are wholly based. In case of matter moving through matter, we trace the same truth under the familiar experience that any breach made by one solid through another, or any channel formed by a fluid through a solid, becomes a route along which, other things being equal, subsequent movements of like nature take place. And in the case of motion passing through matter under the form of an impulse communicated from part to part, the facts of magnetization go to show that the establishment of undulations along certain lines determines their continuance along those lines.

"It further follows from the conditions, that the directions of movement can rarely, if ever, be perfectly straight. For matter in motion to pursue continuously the exact line in which it sets out, the forces of attraction and repulsion must be symmetrically disposed around its path; and the chances against this are infinitely great. The impossibility of making an absolutely true edge to a bar of metal—the fact that all which can be done by the best mechanical appliances is to reduce the irregularities of such an edge to amounts that cannot be perceived without magnifiers—sufficiently exemplifies how, in consequence of the unsymmetrical distribution of forces around the line of movement, the movement is rendered more or less indirect." *P.* 225–227.

And again: "Let us pass to the phenomena of the Solar System as now exhibited. Here the general principles above set forth are every instant exemplified. Each planet and satellite has a momentum which would, if acting alone, carry it forward in the direction it is at any instant pursuing. This momentum hence acts as a resistance to motion in any other direction. Each planet and satellite, however, is drawn by a force which, if unopposed, would take it in a straight line towards its primary. And the resultant of these two forces is that curve which it describes—a curve manifestly consequent on the unsymmetrical distribution of forces around its path." *P.* 228.

§ 463. From these extracts it is evident in the first place, that Mr. Spencer is laboring with old erroneous Newtonian theories of *attraction* and *inertia.*

§ 464. In the next place all the phenomena referred to, and much more which he instances in the chapter, is fully explained by the doctrine of the parallelogram of forces, as heretofore remarked, and as has already been shown as regards planetary motions. It is true that the universe is full of forces acting in all conceivable directions, and that any motion is the resultant or diagonal of the forces acting (and as a consequence, in every composition, forces are dissipated and lost), but how does this tend, in the least, to explain the present arrangement of matter? The explanation must be sought back of all this in the origin and characters of the respective forces at work. A deeper philosophy is demanded.

§ 465. I dissent from Mr. Spencer, also, on his opening proposition: "Matter cannot be conceived except as manifesting forces of attraction and repulsion." We have already learned that we do not conceive of matter as manifesting forces at all, and physicists seem to have very clear notions of a species of matter, called ether, which is supposed to fill all space without manifesting any of the forces of attraction or repulsion.

It may be that in all matter with which we are familiarly acquainted, there dwell both attractive and repulsive forces. I think there is no difficulty in grasping that thought, as in a hot bar of iron for instance, where Cohesion draws the molecules together and Heat pushes them apart, first one gaining on the other and then the reverse. But if the attempt is made to invest the molecules of the iron themselves simultaneously with the inherent principles of both forms of force, Mr. Spencer's difficulty at once appears and does indeed seem insuperable. The gist of the trouble. however, lies in making matter the very essence of force, or force the essence of matter, whichever way they may be regarded, instead of considering them diverse orders of existence.

§ 466. It is not correct to say, that "Movement set up in any direction is itself a cause of further movement in that direction." In unresisted motion the force causing it will continue it in the initiatory direction. Where one body has penetrated another, motion will be more likely in the old path, because the fibers having been once broken there they are likely to present less resistance than on any other line, and the line of least resistance is that path which is the resultant of the moving force and all the resisting forces. Many a rifleman has missed his mark because a part of the force of the moving bullet was lost in overcoming the resistance of a diminutive twig, intervening on one margin of its path, thus throwing the resultant in a different direction. Many a woodman has chopped off his foot by reason of his axe being turned aside by a like impediment.

So there seems to be no basis for an argument in all this mass of verbiage. It is simply taking a familiar philosophical principle, dressing it in new terms, and holding it forth as a full explanation of physical phenomena.

§ 467. On page 231, Mr. Spencer quotes at length from Mr. James Hinton in proof of the following propositions:

"'Organic form is the result of Motion.'

'Motion takes the direction of least resistance.'

'Therefore organic form is the result of motion in the direction of least resistance,' or in the line of the resultant of tractive and resistant forces," as Mr. Spencer renders it. Mr. Hinton's form of proposition is not true at all, and Mr. Spencer's is but again calling on the law of the parallelogram of forces. Neither is going back to the origin and nature of the forces engaged. It is only saying that in organic growth there are a variety of forces employed of which the line of motion is always the resultant or diagonal. And the same may be said precisely of the building of a house or a bridge. But will that explain anything of the forces, causes, and motions, back of the enterprise, or of their origin and history?

Persistence the Primordial Truth.

§ 468. Mr. Spencer, going back for a bed-rock to start this argument from again strikes Persistence of Force. He says: "And now of the general truth set forth in this chapter, as of that dealt with in the last,—let us ask—what is our ultimate evidence? Must we accept it simply as an empirical generalization? or may it be established as a corollary from a still deeper truth? The reader will anticipate the answer.

We shall find it deducible from that datum of consciousness which underlies all science.

"Suppose several tractive forces, variously directed, to be acting on a given body. By what is known among mathematicians as the composition of forces, there may be found for any two of these, a single force of such amount and direction as to produce on the body an exactly equal effect. If in the direction of each of them, there be drawn a straight line, and if the lengths of these two straight lines be made proportional to the amounts of the forces; and if from the end of each line there be drawn a line parallel to the other, so as to complete a parallelogram; then the diagonal of this parallelogram represents the amount and direction of a force that is equivalent to the two. Such a resultant force, as it is called, may be found for any pair of forces throughout the group. Similarly for any pair of such resultants a single resultant may be found. And, by repeating this course, all of them may be reduced to two. If these two are equal and opposite—that is, if there is no line of greatest traction, motion does not take place. If they are opposite but not equal motion takes place in the direction of the greater. And if they are neither equal nor opposite, motion takes place in the direction of their resultant. For in either of these cases there is an unantagonized force in one direction. And this residuary force that is not neutralized by an opposing one must move the body in the direction in which it is acting. To assert the contrary is to assert that a force can be expended without effect--without generating an equivalent force; and by so implying that force can cease to exist, this involves a denial of the persistence of force. It need scarcely be added that if in place of tractions we take resistances, the argument equally holds; and that it holds also where both tractions and resistances are concerned. Thus the law that motion follows the line of greatest traction, or the line of least resistance, or the resultant of the two, is a necessary deduction from that primordial truth which transcends proof." *P*. 245.

And again: "From this primordial truth, too, may be deduced the principle that motion once set up along any line, becomes itself a cause of subsequent motion along that line. The mechanical axiom that, if left to itself, matter moving in any direction will continue in that direction with undiminished velocity, is but an indirect assertion of the persistence of force; since it is an assertion that the force manifested in the transfer of a body along a certain length of a certain line in a certain time, cannot disappear without some equal manifestation—a manifestation which, in the absence of conflicting forces, must be a further transfer in the same direction with the same velocity." *P.* 247.

§ 469. Mr. Spencer is wrong in saying the "diagonal" represents the amount and direction of a force which is equivalent to the two "compositing forces, for, as we have elsewhere seen, in amount it bears the same ratio to the sum of the two original forces that the length of the diagonal bears to the sum of two adjacent sides of the parallelogram; and in every composition of forces a certain amount of force is lost, becomes untraceable, and so far as we can know nonexistent in the material universe, represented by the difference between the length of the diagonal and the sum of the two sides. If it persists we do not and cannot know it; we lose all sight of it; we can take no further account of it; in all physical calculations we are authorized to say *it does not persist.* And Mr. Spencer seems almost to admit this in spite of himself when he says: "For in either of these cases there is an *unantagonized force in one direction.* And this *residuary* force that is not *neutralized* by an opposing one, must move the body in the direction in which it is acting." The truth is, as heretofore insisted upon, that force acting in any direction will continue to act in that direction until withdrawn, neutralized, or composited with some other force; in the latter case a portion always being neutralized.

Rhythm of Motion.

§ 470. Mr. Spencer devotes a chapter to the Rhythm of Motion, showing that all motion is more or less rhythmic, vibratory, or undulatory, and finding the basis of this likewise in the Persistence of Force. He illustrates this, as shown elsewhere, by the tuning fork; and I have shown that, instead of that proving Persistence of Force, it proves the contrary, the antagonism and exhaustion of forces.

He says, page 271: "Thus, then, rhythm is a necessary characteristic of all motion. Given the coexistence everywhere of antagonistic forces—a postulate which,as we have seen, is necessitated by the form of our experience—and rhythm is an inevitable corollary from the persistence of force."

That there are counteracting forces everywhere present is not controverted, nor is the proposition that in consequence the speed and direction of all motion are subject to continual change, but that this change is always subject to periodicity, either as regards time, speed, or direction, which is necessary to true rhythm, cannot be established. For instance, uplands and mountains are being denuded and carried into the sea to build new land without any possibility in the present system and frame of nature for the particles thus borne away ever to be restored to their original place. Thus while very much of the motion in nature may be undulatory and rhythmic, thousands of illustrations may be called up to show that it is not all so.

§ 471. But for the argument, granting Mr. Spencer's contention, instead of proving persistence of force it shows that there is everywhere, at all times, in all motion, a loss and dissipation of force by opposition or composition, that force is continually and everywhere exhausted, worn out, and wasted in the very production of the rhythm which he claims grows as a necessary incident out of the universal persistence of force.

Motion and Force One.

§ 472. The prescribed limits of this work will not permit us to enter into an analysis and discussion of all Mr. Spencer's deductions contained in the latter half of the work, all drawn from the supposed law of the persistence of force, some erroneous, some ingenious and some profound. But I shall note a few of his hypotheses along the way which strike me as being antagonistic to true philosophic principles.

One thing continually apparent is the confounding of *force* and *motion*, and the treatment of motion as though it were a material element. Thus on page 284, speaking of organic bodies, he says: "While, like inorganic aggregates, they passively give off and receive motion, they are also active absorbers of motion latent in food, and active expenders of that motion."

On page 289: "An aggregate that is widely diffused, or but little integrated, is an aggregate that contains a large quantity of motion—actual or potential or both."

On page 542 he says: "By these considerations we were brought within view of the formula. For if it had to comprehend the entire progress from the imperceptible to the perceptible, and from the perceptible to the imperceptible; and if it was also to express the continuous re-distribution of Matter and Motion; then, obviously, it could be no other than one defining the opposite processes of concentration and diffusion in terms of Matter and Motion. And if so, it must be a statement of the truth that the concentration of Matter implies the dissipation of Motion, and that, conversely, the absorption of Motion implies the diffusion of Matter.

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"Evolution and Dissolution, as we name these opposite transformations, though thus truly defined in their most general characters, are but incompletely defined; or rather, while the definition of Dissolution is sufficient, the definition of Evolution is extremely insufficient. Evolution is always an integration of

Matter and dissipation of Motion; but it is in most cases much more than this. The primary redistribution of Matter and Motion is usually accompanied by secondary re-distributions."

And again, on page 543: "The integration of Matter and concomitant dissipation of Motion, was traced not in each whole only, but in the parts into which each whole divides."

§ 473. But, waiving all this verbal inaccuracy the fundamental principle running through the latter half of "First Principles" is the presence everywhere of two antagonistic forces, the repulsive force of heat and the forces of gravitation and cohesion. Mr. Spencer traces with great skill, and learning the results of the continual counteraction of these forces as the one or the other may be in excess, and he finds the sufficient cause and explanation of it all in the *persistence of force.*

But we have already seen that while there is a continual dissipation of heat force by radiation into space there is at the same time a continual dissipation of cohesive force wherever cohesion is antagonized; so here again these very principles which Mr. Spencer deduces from Persistence of Force demonstrates the dissipation and loss of force in the practical workings of nature.

§ 474. But again for the argument, granting Mr. Spencer's contention that all Force persists, how does this in any manner or to any extent account for the variety in the forms of force, of gravitation, cohesion, heat, light, electricity, magnetism? or for the metamorphosis of one form of force into another? Given the postulate of the universal Persistence of Force or Energy, we may say of any particular form of force as a ray of light, or a *quantum* of heat that it must have been heretofore and will be hereafter, but how will that account for its particular and peculiar characteristics? or for the fact that it heretofore did and hereafter will exist as a different mode of force?

Is it not evident that the doctrine of the Persistence of Force, if universally true as contended for, would not and could not account for these further principles of variety and metamorphosis of forces which admittedly lay at the very foundation of material creation?

It follows, therefore, that before starting out to account for the material universe by the interaction, counteraction and mutual transformation of these various forms of Force it is incumbent upon Mr. Spencer to account for these forms of force themselves, as well as for their various metamorphoses from one form into another. He says they are the necessary principles, outgrowths or results of Persistence of Force—but how or wherein? He has not attempted to explain. And as we have seen Persistence of Foree is but a very partial doctrine, unequal to the support of a philosophical superstructure.

§ 475. But suppose we grant not only the universal Persistence of Force, but the necessary diversity and characteristics of the different forces as we find them, and the laws of their transformation as well, what then? How can it be shown that oxygen, hydrogen, or nitrogen, potassium, sodium, or sulphur, iron, copper, or zinc, is the necessary result of the action, interaction, or counteraction, of any or all of these forces? How do any or all of them account for the laws of crystallization? Why does one salt crystallize into a cube and another into an octahedron? How do they account for the laws of chemical affinity? Is it not patent that there is a vast amount of phenomena lying right at the threshold of material creation that the simple existence of these forces and their transformations do not account for?

It follows, therefore, that, granting Mr. Spencer all he claims, and much more, he has a broad and deep chasm to bridge, before he gets fairly started in the task of creating the universe by Evolution.

§ 476. But let us go a step further and grant that "existences of all orders *do* exhibit a progressive integration of Matter and concomitant loss of Motion," p. 307, or, to put it more clearly, that in all bodies there has been a concentration of matter upon the loss or dissipation of heat-force. How will that account for the form and characteristics of bodies? And particularly how will it account for organic growth? In the growth of an apple there is undoubtedly a concentration of matter, and so far as the same is solidified from liquids or gases, a dissipation of heat-force, but wherein the explanation here of its growth? Why is it an apple instead of a peach, a pear, or a plum? Why does the concentration take the form of a fruit at all instead of leaves or wood? And why is there any concentration at all? Why is nutriment taken up by the roots, carried upward by the stem, digested, combined, and transformed by the leaves, and then redistributed, some utilized in making root, some stem, some buds, some leaves, some fruit and seed? Does the fact of the "progressive integration of Matter and concomitant loss of Motion" explain it? Assuredly not. These may be steps in the operation, or rather a general formula equivalent to the proposition that the apple grows by the coincident dissipation of heat-force and solidification of Matter, but the how, the why, the cause, is utterly ignored.

Mr. Spencer says: "Evolution then, under its primary aspect, is a change from a less coherent form to a more coherent form, consequent on the dissipation of motion and integration of matter. This is the universal process through which sensible existences, individually and as a whole pass, during the ascending halves of their histories." *P* 327.

Grant that it is a general formula for the process, we have just seen that it offers no explanation of the cause.

§ 477. Mr. Spencer says: "Hence the general formula arrived at in the last chapter needs supplementing. It is true that Evolution, under its primary aspect, is a change from a less coherent form to a more coherent form, consequent on the dissipation of motion and integration of matter; but this is by no means the whole truth. Along with the passage from the incoherent to the coherent, there goes on a passage from the uniform to the multiform. Such, at least is the fact, wherever Evolution is compound; which it is in the immense majority of cases. While there is a progressing concentration of the aggregate, either by the closer approach of the matter within its limits, or by the drawing in of further matter, or by both; and while the more or less distinct parts into which the aggregate divides and subdivides are severally concentrating; these parts are also become ing unlike—unlike in size, or in form, or in texture, or in composition, or in several or all of these. The same process is exhibited by the whole and by its members. The entire mass is integrating, and simultaneously differentiating from other masses; and each member of it is also integrating and simultaneously differentiating from other members.

"Our conception, then, must unite these characters. As we now understand it, Evolution is definable as a change from an incoherent homogeneity to a coherent heterogeneity, accompanying the dissipation of motion and integration of matter. *P.* 360.

On Page 362 he says: "At the same time that Evolution is a change from the homogeneous to the heterogeneous, it is a change from the indefinite to the definite. Along with an advance from simplicity to complexity, there is an advance from confusion to order—from undetermined arrangement to determined arrangement. Development, no matter of what kind, exhibits not only a multiplication of unlike parts, but an increase in the distinctness with which these parts are marked off one from another."

On Page 396 he says: While, there, we have to contemplate the matter of an evolving aggregate as undergoing, not progressive integration simply, but as simultaneously undergoing various secondary re-distributions, we also have to contemplate the motion of an evolving aggregate, not only as being gradually dissipated, but as passing through many secondary re-distributions on the way towards dissipation. As the structural complexities that arise during compound evolution are incidental to the progress from the extreme of diffusion to the extreme of concentration; so the functional complexities accompanying them, are incidental motives to the progress from the greatest quantity of contained motion to the least quantity of contained motion. And we have to state these concomitants of both transformations, as well as their beginnings and ends.

"Our formula, therefore, needs an additional clause. To combine this satisfactorily with the clauses as they stand in the last chapters is scarcely practicable; and, for convenience of expression, it will be best to change this order. Doing this, and making the requisite addition, the formula finally stands thus:—*Evolution is an integration of matter and concomitant dissipation of motion; during which the matter passes from an indefinite incoherent homogeneity to a definite coherent heterogeneity; and during which the retained motion undergoes a parallel transformation.*

Now, as so often insisted upon, all this is but a "*formula*," it explains nothing, shows no cause, no reason why, no wherefore. But following Mr. Spencer we shall find that he attempts to give us the wherefore.

§ 478. He says: "Is this law ultimate or derivative? Must we rest satisfied with the conclusion that throughout all classes of concrete phenomena such is the course of transformation? Or is it possible for us to ascertain *why* such is the course of transformation? May we seek for some all-pervading principle which underlies this all-pervading process? Can the inductions set forth in the preceding four chapters be reduced to deductions?

"Manifestly this community of result implies community of cause. It may be that of such cause no account can be given, further than that the Unknowable is manifested to us after this mode. Or it may be that this mode of manifestation is reducible to a simpler mode, from which these complex effects follow. Analogy suggests the latter inference. Just as it was possible to interpret the empirical generalizations called Kepler's laws, as necessary consequences of the laws of gravitation; so it may be possible to interpret the foregoing empirical generalizations as necessary consequences of some deeper law." *P.* 397.

And, again: "The task before us, then, is that of exhibiting the phenomena of Evolution in synthetic order. Setting out from an established ultimate principle, it has to be shown that the course of transformation among all kinds of existences, cannot but be that which we have seen it to be. It has to be shown that the re-distribution of matter and motion must everywhere take place in those ways, and produce those traits, which celestial bodies, organisms, societies, alike display. And it has to be shown that this universality of process results from the same necessity which determines each simplest movement around us down to the accelerated fall of a stone or the recurrent beat of a harp-string.

"In other words, the phenomena of Evolution has to be deduced from the Persistence of Force. As before said—'to this an ultimate analysis brings us down; and on this a rational synthesis must build up.' This being the ultimate truth which transcends experience by underlying it, so furnishing a common basis on which the widest generalizations stand, these widest generalizations are to be unified by referring them to this common basis. Already the truths manifested throughout concrete phenomena of all orders, that there is equivalence among transformed forces, that motion follows the line of least resistance, and that it is universally rhythmic, we have found to be severally deducible from the persistence of force; and this affiliation of them on the persistence of force has reduced them to a coherent whole. Here we have similarly to affiliate the universal traits of Evolution, by showing that, given the persistence of force, the re-distribution of matter and motion necessarily proceeds in such way as to produce them; and by doing this we shall unite them as co-relative aspects of our law, at the same time that we unite this law with the foregoing simpler laws." *P.* 398, 399.

§ 479. In other words, in Persistence of Force he is going to find all explanation, all cause, all reason for all phenomena, and all existence: thus still ignoring the *why* of the diversity of distinctly characterized forces in nature as well as the law and nature of their transformation. His argument all along is that the proposition of the Persistence of Force accepted by him, not only as a fact, but a universal and fundamental fact, necessitates the further acceptance of the proposition that out of that doctrine grows those phenomena of force which he variously styles Continuity of Motion, Persistence of Relations among Forces, Transformation and Equivalence of Forces, Rhythm of Motion, Instability of the Homogeneous, Segregation, Multiplication of Effects, etc., and that these various phenomena of necessity produce Evolution.

Continuity of Motion.

§ 480. The Continuity of Motion is the necessary result ofthe laws of Force and Inertia already discussed. When motion is once set up in a body the force which initiates it will continue it in the same right line and with the same velocity until composited with other forces, or dissipated by resistance from other forces, which last expression is but a particular case of composition otherwise called the Parallelogram. So Continuity of Motion, as long as it lasts, *is* dependent on the Persistence of Force, and so long as force does persist, it necessitates Continuity of Motion ; and the sole reason why all motion is not continuous is that forces do cease to persist by reason of dissipation in Composition.

§ 481. But this is not the sense in which Mr. Spencer uses the phrase Continuity of Motion. He means to say that whenever motion disappears in one form it reappears in another and that this phenomenon is due to the Persistence of Force. But the first part of the proposition is not true. Motion is continually disappearing without ever again becoming traceable, and this by reason of the law of the Parallelogram. Indeed, we have seen elsewhere that there is no such thing at all as the motion of one body appearing in another, that force may be transferred but motion cannot be. The proposition is, therefore, meaningless, and all the circumstances of the phenomena are explicable on the principles of Composition.

Persistence of Relations.

§ 482. By "Persistence of Relations Among Forces" Mr. Spencer seems to mean that like forces operating in like direction will produce like motions which is only asserting the truism that like things are like. This is not an explanation nor even a tendency towards the explanation of anything.

Transformation.

§ 483. "Transformation and Equivalence of Forces," instead of being a derivation from the Persistence of Force, is simply another expression for that doctrine itself. Of course, if forces persist, there must be continuous transformations all around and an exact equivalence of such force before and after the transformation. *Contra*, just so far as transformations do occur in which equivalence is maintained, only so far does the doctrine of Persistence hold good. It has been abundantly shown that in radiation and pressure, as well as in all characters of Composition, forces are continually dissipated, so far, at least, as to be lost to observation, and so far as we have any means of knowing, absolutely annihilated. It may be again remarked that giving a new expression to an old principle explains nothing and is not in the vicinage of the pathway to a true philosophy.

Direction of Motion.

§ 484. Mr. Spencer defines the "Direction of Motion as being in the line of the greatest traction or of the least resistance or in that of the resultant of these two conditions." In this he is strictly correct; but it is all only another way of saying that motion is always on the line of the common diagonal or resultant of all the forces concerned. This is patent in tractions and will become so in all resistances when it is remembered that resistance is nothing more than Composition with the angle of incidence greater than ninety degrees. This is, therefore, but again giving another new expression to the doctrine of the Parallelogram, with the result of obscuring rather than elucidating the principle.

Rhythm.

§ 485. "The Rhythm of Motion" is a necessary result of the varying intensities and directions of the forces acting on matter. It is governed strictly by the great Law of Composition or the Parallelogram wherein by reason of the constant variance of the intensities and directions of the forces acting upon any body, the diagonal or resultant is constantly varying. The deeper causes lie back, of course, in the variance of the intensities and directions of the operative forces. These causes are, principally; 1st, The dissipation of heat-force by radiation; 2nd, The law of the inverse square of the distances in Gravitation, and 3rd, The dissipation of force in Composition. It has already been shown that momentarily, both the distance and direction of each atom varies from every other in the Universe, and that, therefore, the gravitative intensities vary in the same manner with the consequent continual variation of the resultant diagonal of actual motion.

Hence it follows that Rhythm is not the result of the Persistence of Force, as contended by Mr. Spencer, but precisely the contrary. It is a necessary law from the fact of the continual dissipation of forces. If forces were not continually dissipated and renewed, they would eventually find their balance and put an end to instability, as water finds its level and there rests.

Instability.

§ 486. "The Instability of the Homogeneous" arises from the same principles and others to be mentioned. The continual change of intensities and directions of all forces, coupled with their continual dissipation, necessarily tends to break up all homogeneity and render all bodies unstable. But back of all this there are certain laws of atomicity, molecularity, crystallization, and cohesion, which, when the repulsive heat forces are sufficiently dissipated, cause the atoms of homogeneous matter to fall and cling together, forming first the molecules of the elements, next the molecules of the various chemical compounds, then crystals of different substances, and finally uncrystallized bodies. But these varying grades of integration are each and all liable to be overcome and dissolved by an excess of heat-force. And wherever forces oppose and antagonize there is consequent dissipation and loss. And for this very reason the homogeneous is unstable. The intensity of all the forces concerned necessarily vary by reason of the dissipation by antagonisms, as well as by radiation and gravitation laws, while stability is dependent upon the uniform intensities of all the forces actively employed.

§ **487.** And so with all the other phases or results of motion discussed by Mr. Spencer and by him accounted for by Persistence. The reason and philosophy of each and all of them lie in the exact opposite. They arise out of the law of composition as resultants of opposing and mutually destructive antagonisms of forces. Thus Mr. Collins says: "The multiplication of effects is a corollary from the persistence of force." *Synthetic Philosophy, p.* 53. And on p. 50: "Thus when one body is struck against another, there may be besides the mechanical result, sound, air-currents, fracture, incandescence, and chemical combination. And incident force decomposed by the reactions of a body into a group of unlike forces—a uniform force thus reduced to a multiform force—becomes the cause of a secondary increase of multiformity in the body which composes it." True, but what causes this breaking up of a "uniform force" into "multiform forces?" Evidently the resistance offered by the forces resident in the passive body, and in the process there is a composition and dissipation of forces by the law of the Parallelogram, so that the phenomena are due, primarily, not to Persistence but to the lack of Persistence.

§ 488. And so with "Segregation," "Equilibration," and "Dissolution"; they are each the result of the antagonism and dissipation of forces in composition. Examples of Segregation are given by Mr. Spencer and Mr. Collins in the sorting of drift and shingle by wind and wave. The principle, however, lies in the fact that the greater the resistance offered to the forward force, the more of it is dissipated in composition and the less of it is left to move the particular body onward. On the subject of Equilibration Mr. Collins seems to concede that "antagonist forces" "are expended in overcoming resistances," and this, and not Persistence, is the very principle out of which Equilibration grows. And so "Dissolution" is the result of a struggle between heat-force on one side and chemism and cohesion on the other in which the latter forces are overcome, dissipated, and apparently lost.

And in this way, by applying abstract terms to concrete facts, Mr. Spencer has been able to give a semblance of verity to a philosophy reared upon a single proposition as an ultimate truth, and that proposition the very reverse of reality. Indeed, Mr. Spencer's system is a vast intellectual edifice, built up of abstractions so ingeniously compacted together by the use of ponderous verbiage, that even the closest analysis finds access to the blank and vacuous interior with difficulty.

CHAPTER XXIII.

LAW.

THE DUKE OF ARGYLL—LAWS OF NATURE ETERNAL —FOREORDAINED—PERSONALLY ADMINISTERED.

Laws of Nature.

§ 489. THE most potent term in philosophy is, "The Laws of Nature." Whenever it can be asserted that any assumed principle is "A Law of Nature," that is supposed to be not only "the end of the law" but the end of explanation as well. It is considered the final term of all discussion in physics or metaphysics.

§ 490. Law is well defined "a rule of action." In nature it means the rule by which, the line upon which, or the groove in which, some natural force operates, or it may be said to be the essential character of some active force in nature, because any such force must act according to its character; or, expressed differently yet, its character is determined by the manner of its action. From which it follows that the law governing any such force cannot be eliminated from the force, for its roots are deep down in the essence of the force itself.

§ 491. Prof. Huxley says: "The tenacity of the wonderful fallacy that the Laws of Nature are agents instead of being, as they really are, a mere record of experience, upon which we base our interpretations of that which does happen and our anticipations of that which will happen is an interesting psychological fact, and would be unintelligible if the tendency of the human mind toward realism were less strong.

"In fact, the habitual use of the word 'law,' in the sense of an active thing, is almost a mark of pseudo-science; it characterizes the writings of those who have appropriated the forms of science without knowing anything of its substance." *P. S. M., April*, 1887, *p.* 794.

In this he is right in deprecating the use of the term Law as "an active thing," but, as we shall see, probably not right in his notion of the general scope of the Laws of Nature.

§ 492. The Duke of Argyll distinguishes "five different senses in which Law is habitually used:"

"First, we have Law applied to an observed Order of Facts.

"Secondly, to that order as involving the action of some Force or Forces of which nothing more may be known.

"Thirdly, as applied to individual Forces the measure of whose operation has been more or less defined or ascertained.

"Fourthly, as applied to those combinations of Force which have reference to the fulfillment of purpose or the discharge of function.

"Fifthly, as applied to Abstract Conceptions of the mind—not corresponding with any actual phenomena, but deduced therefrom as axioms of thought necessary to our understanding of them. Law, in this sense, is a reduction of the phenomena not merely to an Order of Facts, but to an Order of Thought." *Reign of Law*, *p.* 39.

§ 493. As illustration of the first sense he instances the Three Laws of Kepler. "These Laws were simply and purely an 'Order of Facts' established by observation, and not connected with any known cause. The Force of which that Order is a necessary result had not then been ascertained. A very large proportion of the laws of every science are laws of this kind and this sense. For example, in chemistry the behavior of different substances towards each other in respect to combination and affinity, is reduced to system under laws of this kind and of this kind only." *Ibid*, *p*. 41.

§ 494. Of the second sense, Argyll says: "An observed Order of Facts, to be entitled to the rank of a Law, must be an Order so constant and uniform as to indicate necessity, and necessity can only arise out of the action of some compelling Force. Law, therefore, comes to indicate not merely an observed Order of Facts, but that Order as involving the action of some Force or Forces, of which nothing more may be known than these visible effects. Every observed Order in physical phenomena suggests irresistibly to the mind the operation of some physical cause. We say of an observed Order of Facts that it must be due to some 'law,' meaning simply that all Order involves the idea of some arranging cause, the working of some Force or Forces (whether they be such as we can further trace and define or not) of which that Order is the index and the result. This is the second of the five senses specified above." *Ibid*, 41.

§ 495. He thus discusses Law in the third sense: "Of Law in this sense the one great example, before and above all others, is the Law of Gravitation, for this is a Law in the sense not merely of a rule, but of a cause—that is, of a Force accurately defined and ascertained according to the measure of its operation, from which Force other phenomena arise by way of necessary consequence. Force is the root-idea of Law in its scientific sense. And so the Law of Gravitation is not merely the 'observed order' in which the heavenly bodies move; neither is it only the abstract idea of some Force to which such movements must be due, but it is that Force the exact measure of whose operation was numerically ascertained or defined by Newton—the Force which compels these movements and (in a sense) explains them. Now the difference between Law in the narrower and Law in the larger sense cannot be better illustrated than in the difference between the three special Laws discovered by Kepler, and the one universal Law discovered by Newton. The three laws of Kepler were, as we have seen, simply and purely an observed Order of Facts. They stood by themselves—disconnected,—their cause unknown. The higher Law, discovered by Newton, revealed their connection and their cause. The 'observed Order' which Kepler had discovered was simply a necessary consequence of the Force of Gravitation. In the light of this great Law the 'Three Laws of Kepler' have been merged and lost." *Ibid*, 42.

§ 496. He thus explains the fourth sense in which Law is used: "No one Law—that is to say, no one Force—determines anything that we see happening or done around us. It is always the result of different and opposing Forces, nicely balanced against each other. The least disturbance of the proportion in which any one of them is allowed to tell, produces a total change in the effect. The more we know of nature, the more intricate do such combinations appear to be. They can be traced very near to the fountains of Life itself, even close up to the confines of the last secret of all—how the Will acts upon its organs in the Body.

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"What we always reach at last in the course of every physical inquiry is the recognition, not of individual laws, but of some definite relation to each other, in which different laws are placed, so as to bring about a particular result. But this is, in other words, the principle of Adjustment, and adjustment has no meaning, except as the instrument and the result of Purpose. Force so combined with Force as to produce certain definite and orderly results,—this is the ultimate fact of all discovery.

"And so we come upon another sense—the Fourth sense, in which Law is habitually used in Science, and this is perhaps the commonest and most important of all. It is used to designate not merely an observed Order of Facts—not merely the bare abstract idea of Force—not merely individual Forces according to ascertained measures of operation—but a number of forces in the condition of mutual adjustment, that is to say, as combined with each other, and fitted to each other for the attainment of special ends. The whole science of Animal mechanics, for example, deals with law in this sense—with natural Forces as related to Purpose and subservient to the discharge of function." *Ibid, p.* 46.

§ 497. And he thus discusses the fifth sense attached to Natural Law: "And this brings us to the Fifth meaning in which the word Law is habitually used in Science,—a meaning which is indeed well deserving of attention. In this sense, Law is used to designate, not any observed Order of Facts,—not any Force to which such Order may be due,—neither yet any combination of Force adjusted to the discharge of function, but some purely Abstract Idea, which carries up to a higher point our conception of what the phenomena are and of what they do. There may be no phenomena actually corresponding to such Idea, and yet a clear conception of it may be essential to a right understanding of all the phenomena around us. A good example of Law in this sense is to be found in the law which in the Science of Mechanics, is called the First Law of Motion. The law is, that all Motion is in itself (that is to say, except as affected by extraneous Forces) uniform in velocity, and rectilinear in direction. Thus, according to this law, a body moving, and not subject to any extraneous Force, would go on moving forever at the same rate of velocity, and in an exactly straight line.

"Now, there is no such motion as this existing on the earth or in the heavens. It is an Abstract Idea of Motion which no man has ever, or can ever, see exemplified. * * * * * It represents a Rule which never operates as we conceive it, by itself, but is always complicated with other Rules which produce a corresponding complication in result. Like many other laws of the same class, it was discovered not by looking outwards, but by looking inwards; not by observing but by thinking." *Ibid*, *p*. 65.

Three Doctrines of Law.

§ 498. These views of the Duke of Argyll are not only profound, but in the main, just. The higher aspect of Law as we know it is an adjustment or co-ordination of forces resulting in the system of nature as we see it. But there are three ways of regarding this "higher Law," and consequently three schools of thought regarding it. The first view is that the co-ordination comes about necessarily by reason of laws inherent in the very essence of the several forces, and coeval with their very eternity. The second view is that at some period in the past a Divine Power either created the forces of nature or gave them form and rule, stamping upon their very essence at the time, severally, the destiny which compels all the co-ordinations and adjustments of all the circling eons after, and having fixed them "fast in fate" by the lines of action impressed upon them, abandoned them to their several courses ever after.

The third view is, that the adjustments of Nature's laws are under the immediate and personal control of an omniscient and omnipotent Ruler of the Universe, an All-wise and All-powerful Law-giver and Law-enforcer.

§ 499. It will be observed that the only difference between the first two theories is, that in one the great Wheel of Destiny is started on its endless rounds by Deity, and in the other without Deity; in one the Machine was set in motion by a personal Creator, in the other by Chance. After it is set in motion, there is, and can be, no difference, for a Deity who has irrevocably tied His own hands and enchained His own will by framing all nature into a code of rule and law at the beginning, which he cannot, and will not, in any event, forego or undo, is to Nature ever after, as though He were not. In the very act of fore-ordaining and predestinating the rule of action for all forces and the course of all Nature, He has cast the frame of the Universe in a mould of Fate as surely and irrevocably as if it came from the relentless hands of an eternal and causeless destiny.

§ 500. Then in the light of Nature's adjustments, so ably elucidated by the Duke of Argyll, what do these two theories, which are one, demand of our credulity? As we have so frequently noticed, it can no longer be claimed that no forces are lost to the sum total of the original store, because, to say nothing of the various other losses in this work demonstrated, of the universally admitted loss from heat-radiation. But for the purposes of the present argument, it is conceded that no new forces have ever come into existence or ever will do so.

§ 501. Then let us look forward six centuries to the year, A. D. 2500. When that year opens upon terrestrial affairs this world will have changed very considerably from what it is to-day. Not an animal, and perhaps not a plant, now in existence will then be living. Perhaps many races of beings now inhabiting land and water will have become extinct while others will have taken their places. Physical causes will have very materially changed the Earth's surface, while man will have changed it more; for no doubt, he will have brought nature's forces under the dominion of his will to a far greater extent than now.

Art, Science, Civilization, Society, and Government, will be greatly altered and in many respects advanced. But whatever the outcome may then be, if either of these theories be true, all the causes and forces by which these great changes will have been produced are now existent and in active operation in the material universe. It will all be the result, and the necessary result, of the mutual action and interaction, resistence and co-ordination of these now existing forces. The paths and courses which any and all of these forces must necessarily take during the whole period, are already determined and marked out. Take the minutest organ of the minutest animal form, or the tiniest flower of grass or herb, observe the myriad forces great and small concerned in fitting each particle for its place and in its place in the organism, trace them all back to the present moment, their paths will be found intricate and sinuous, crossing and recrossing, lacing and interlacing, co-ordinating, combining, separating, and opposing, until *now* they would be found scattered in countless millions of directions, but each containing in itself the necessity for the exact line of march it is to take, and in its bosom the potentiality of its part of the future organic form. And this necessity of its exact line of forward march is the law of its being, the necessary rule of its action. So that, if all these numberless myriads of forces could *now* be marshalled and gathered together, and all their necessary lines of sinuous action traced, they would be found to converge, culminate, and result in that organism, so that it will be, or rather is, an absolute and inevitable necessity from the order of things at this moment existing. And so of every other organic form, animal, or vegetal, that will then exist, and every material, social, or political change in affairs then to be found. And as with affairs in . D. 2500, just so 2500 million years from now, if the world shall stand so long. And as with the future, so with the past. Go back 2500 million years, and if the universe then was, all the forces now existent were then, carrying in the very essence of their existence the necessity for all those lines of onward march and forward action which have culminated in the world as we find it. By the argument of all logicians chance is excluded. By the theories under discussion, extraneous interference is excluded. What is left? Simply forces, at all times and in all places acting according to the necessity of their existence, in lines and under laws which they cannot desert or evade. "The whole world living and non-living has resulted from the mutual action and interaction of the forces possessed by the atoms or molecules of which the primitive nebulosity of the universe was composed. It is no less certain that the existing world, lay potentially in the cosmic vapor, and that a sufficient intelligence could, from a knowledge of the properties of the molecules of that vapor, have predicted, say, the state of the fauna of Britain at this day with as much certainty as we can say what will happen to the vapor of breath on a cold winter day."—*Huxley.*

§ 502. What then? One of two conclusions, necessarily. Either these forces, with the necessary laws of their existence and action, were without beginning, eternal, unconditioned and absolute, which is Atheism blank and bald; or else an extraneous power, at that point of time, or some other, earlier or later, designed and formulated the whole plan of all after-creation, and then and there fixed in the various forces the necessary plans, paths, and laws of their all after-action to the present, and on, and on; and having thus fixed and formulated all the after-come for all the after-time, so that no further interference should ever after be necessary, and no breaks in the continuity of action ever after possible, withdrew His hand, then and forever. This is practical Atheism.

The third and converse theory is that there is an extraneous Power who holds all Nature's forces in the hollow of His hand to be directed, modified, and changed to carry out His own plans and designs, in His own way, under laws of His own appointment, given, changed, modified, or revoked as to Him seems well.

§ 503. By the first and second theories the universe is an automaton, a self-acting and self-regulating machine by reason of the self-necessity imposed in the constitution of its own existence; and in both alike, the end is obtained by a cordination and adjustment of forces necessitated by the inherent constitution and essence of their very existence.

§ 504. Then what have we? By the first theory, in the beginning of the infinite eternities we find an infinite series of forces, each independently and without cause, reason, plan, or purpose, having stamped in the very essence of its existence a necessary rule or course of action which should compel it into all the adjustments and co-ordinations, of all the after eternities until *now*, and on, and on, forever. Accident, Happen-so, Fate, or Destiny, call it what you will, so dowered each of these infinite forces, that, pursuing independent and unrelated paths through all the eons, they have, nevertheless, again and again fallen into regular and symmetric adjustment; and again and again divided and separated and met again, until, at last, in this perfectly fortuitous manner, *to-day* they give us every star-twinkle and every sunbeam, every pebble and every gem, every flower and every fruit, every animal, and every organ and function of every animal, the hand, the breath, the brain of man, his thoughts, his emotions, his volitions, his life, his soul. By the theory, not only is it all the result of unformulated law, co-eternal with the first essence of existence itself, with world-stuff when first it took on activity, but of the uncaused and purely accidental co-ordination of independent and unrelated laws, infinite in number and diversity of character. That is to say, by the theory, there is not an individual existence to-day, organic or inorganic, animal, plant, or mineral, not a single organ or function of living Nature in all the infinitude of this and all other worlds, not a system or mechanism, the handicraft of man on earth or of Nature on the earth, in the sea or in the heavens, carrying any similitude of plan or purpose, but that is the result of chance a million times multiplied by chance.

Prof. Goldwin Smith aptly remarks of "the citizen atoms, which, according to Haeckel, while diffused through space, concerted amongst themselves the structure of the world!"

§ 505. The second theory avoids the doctrine of probability, or rather of infinitely utter improbability, upon which the first is based, for, instead of chanceful fate it predicates designed fate. Things are what they are, not because chance fixed them so, but because laws were in the beginning designedly impressed on the infinite of nature's forces which have compelled them to severally pursue the devious paths they have followed for the millions of ages past, until they are forced together in particular co-ordination, as to-day we find them, in any individual existence, organ, or function.

"Leibnitz utterly rejected teleology in the material world. Here, for him, reigns mechanical causality and nothing else. Matter is, according to him, created by God, but at the same time it is so invested once for all with motive force that there is no need of setting the clock of the universe to make it go right." *E. DuBois-Raymond*, *Pop. Sci. M.*, *Feby.*, 1879, *p.* 421.

§ 506. Now when we approach Deity, we cannot build an argument on the supposed finitude or incapacity of the All-Powerful. We cannot say God could not have so impressed laws upon the infinite diversity of forces in the beginning, that, without further attention from Him, they have pursued their several independent courses until they have come together in some beautiful and wonderful adjustment of the present hour. But we are certainly warranted in saying, that such a proposition is so far beyond human comprehension, that its assertion is illogical until it shall be shown that any alternative proposition is impossible. And what would seem to make this hypothesis the next thing to impossible is the fact that nature's forces are not clear cut, individual things, like pebbles or even the molecules or particles of material bodies which may generally take different impressions and be diversely affected, but, on the contrary, entirely homogeneous in essence, so to speak. They separate without distinction and flow together again, commingling without any line of demarkation known to science. The muscular force of a man and a horse may flow together and unite to draw a load or lift a weight without any possibility of any after separation. So the power of the man's arm may be added to the pull of gravity, or of a rubber cord, or the pressure of steam; or any two or more, or all of these forces may act together and lose their identity in doing so, past all recognition by human science. Now if these several forces had several laws stamped upon them in the beginning which they were to carry through all after time and eternity for utilization in co-ordinating with other forces in the production of the purposed mechanism of nature, what becomes of these laws when they flow into and are undistinguishably lost in floods of other forces?

§ 507. But another view is presented. One or the other of these two theories are absolutely necessary to the doctrine of Conservation, and if, as has been contended all the way through this work, Conservation fails by reason of the fact that new forces are continually introduced into the known cosmos in the form of gravitation and other forms of pressure-force, then neither of these two theories can be true, for forces which are not present in the material universe at the period when Nature's forces received their impress of destiny from the hands of Chance, or Deity, as the case may be, cannot have been so stamped, and are, therefore, independent of any such eternally fateful casting. So again we see Conservation standing for inexorable necessity if not for inevitable casualty; standing out against a personal Creator and Governor of the Universe, and against a free will and personality in the breast of man.

"But holding it as equally certain, because the fact is capable of verification by every one as often as he chooses to make the experiment, that, in the performance of every volitional movement, physical force is put in action, directed and controlled by the individual personality, or *ego*, I deem it just as absurd and illogical to affirm that there is no place for a God in nature, originating, directing, and controlling its forces by His will, as it would be to assert that there is no place in man's body for his conscious mind."—*Dr. Wm. B. Carpenter, P. S. M., Mar.*, 1880, *p.* 625.

§ 508. Getting back to the argument, we find certain Laws or Rules of Action stamped upon Nature. What can we say of them? In some aspects but very little, indeed; in other aspects a great deal. We cannot go to their origin. We cannot say whence they came, nor how, nor when. We cannot say whether they are essentially eternal or the products of creative Power. But this we can say, and must say, if we confine ourselves to the logic of the case, that they are only manifested to us in mutual relations and adjustments which cannot have been eternal, which cannot have been arbitrarily fixed, moulded, cast, and abandoned at some particular epoch in the past eternities, but which, on the contrary, must be the outcome of a personal, purposing, supervising Intelligence.

The Duke of Argyll has put the matter exceedingly well: "The Forces by which a watch are moved are natural Forces. It is the relation of interdependence in which those Forces are placed to each other, or, in other words, the adjustment of them to a particular purpose, which constitutes the watch-force; and the seat of this Force is in the Intelligence which conceived that combination, and in the Will which gave it effect. The mechanism devised by man are in this respect only an image of the more perfect mechanism of Nature, in which the same principle of adjustment is always the highest result which Science can ascertain or recognize. There is this difference, indeed,—that in regard to our works we see that our knowledge of natural laws is very imperfect, and our control over them is very feeble; whereas in the machinery of Nature there is evidence of complete knowledge and of absolute control. The universal rule is, that everything is brought about by way of natural consequence. But another rule is, that all natural consequences meet and fit into each other in endless circles of Harmony and of Purpose. And this can only be explained by the fact that what we call Natural Consequence is always the conjoint effect of an infinite number of elementary Forces, whose action and reaction are under the direction of the Will which we see obeyed, and of the Purposes which we see actually attained."—*Reign of Law, p.* 74.

CHAPTER XXIV.

LIFE.

§ 509. In conclusion, Conservation may be considered in one other aspect. Prof. Haeckel, Mr. Hinton, and, as I understand him, Mr. Spencer, also, find no principle in the plant or animal not also present in the crystal. As they regard the matter, all the phenomena of organic growth and development are the simple results of the co-ordinations of the ordinary physical forces of physical nature acting outside the domination of any other principle. With them Life has a single, simple meaning, and may be defined as the phenomena of organic action. But with this view I cannot agree, for I find that while the plant and the animal are built up by the ordinary natural forces, these forces do not here behave as they do in the crystal nor even as they do in the watch. I think I find that in organic creatures they are handled, controlled and adjusted in a manner that does not appear in the crystal nor in the watch; and, therefore, I think I am justified in saying I apprehend a higher principle here not manifested there. For want of a better term, I call this higher principle *Life*, whence, with me, this term comes to have a double meaning; lower, the circle of phenomena manifested in any organic being; higher, the active cause of such phenomena. In this chapter I shall use it with the latter meaning.

§ 510. I will now reach my point of argument by an illustration. Take a single grain of corn:

Within it is *life*, a principle which, when afforded the proper conditions, can command the physical forces of nature in selecting materials from earth and air and out of them building the beautiful stalk of maize with blade and ear; and, not only so, but in fabricating other grains, perhaps a thousand of them, in each of which is enfolded a new but like Life principle. And each of these may in turn be planted with like results.

We start with one life wrapped in a single kernel, within a few months we have a thousand like lives and the second season a million. Now here is an absolute multiplication of this life principle, an absolute coming of *lives* into a first manifestation. They are not, but soon they will be; now they are, but a little while ago they were not. But when these kernels are ground into food for man or beast, or when they develop into stalks and are cut down by the frost, the life in them is gone, and forever. Now whence did it come and where has it flown? Of course this raises a question as inscrutable as those connected with the origin and destiny of Gravity, Cohesion, Elasticity and Pressure-Force.

§ 511. But the point I wish to make is that here is another great, all-pervading and all-powerful principle in nature which, though not a force, is a controller and master of forces, and which is continually coming into sensible nature and as continually going out; and, further, which is to us utterly untraceable at either end of the line. For what is true of the grain of maize is true of every organic individual.

Mr. Darwin has calculated that a single pair of elephants, the slowest breeders of all known animals, would, if favorably circumstanced, in 750 years increase to nineteen million. "Linnaeus has calculated that if an annual plant produced two seeds and their seedlings next year produced two, and so on, then in twenty years there would be a million plants." Mr. Wallace estimates that a pair of birds producing four young per season would in fifteen years increase to two thousand million. But these examples are but feeble illustrations of how earth teems with life. The cod may weigh 100 pounds and it is estimated that the roe of the female contains from four to nine million eggs. Each one of these eggs contains a life and if a single pair of cod could multiply unimpeded it would take but a very few years for them to fill all the waters of earth solid from ocean bed to surface wave. Many other animals are equally prolific or nearly so.

§ 512. When we come to plants we find life crowding in the same manner, since it is not only stored in every kind of seed but every bud is a centre of life, capable, under favorable conditions, of becoming an independent individual. When we get down into the microscopic world life is practically infinite in measure. And as it is now such it has been for the untold ages, so that the solid crust of Earth for miles in thickness is made up of the remains of living beings. And so it is likely to be for all the ages to come.

§ 512. But of all the infinite host now dominating, organizing, and adjusting physical forces into building organic temples—diminutive or grand, common or strange, grotesque or beautiful—as homes for themselves and cradles for their progeny, probably not one, certainly not many, will be found on Earth when the year A. D. 2500 comes around; and perhaps not one, certainly not many of them could have been found here that long ago, It is a flood which everlastingly ebbs and flows, constantly dashing its waves against Mr. Spencer's philosophy and refusing reconciliation with the doctrine of Conservation. Life in this view will not harmonize with Materialism. Materialism can present no basis for it in this sense. Here, as seen all the way through these pages, is the keen logical edge of principle dividing free Personality from mechanical Necessity, Deity from Fate, Soul from the Processes of Physical Mechanism, and the possibility of Immortality from the certain doom of Extinction.

For Life, in this sense of an organizer, controller, and adjuster of physical forces, can by no possibility be traced to any known physical antecedent nor to any known correlated subsequent. Neither in essence nor quantitative correlation can it be found heretofore nor will it be found hereafter. Physical science knows its *now* but not its *heretofore* nor its *hereafter*. Conservation cannot be affirmed of it. Science must here give place to speculation on the one hand or to faith on the other.

THE END.

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